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FLOOD PLAIN MANAGEMENT STUDY

SHIELDS RIVER

Park County, Montana

Prepared by

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
Bozeman, Montana

in cooperation with

Park County
Park Conservation District
Montana Department of Natural Resources and Conservation

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MARCH 1993

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SHIELDS RIVER
Park County, Montana

March 1993

INTRODUCTION

The Shields River study was requested by the Park County Commissioners through the Montana Department of Natural Resources and Conservation (MDNRC). This request was supported by the Park Conservation District.

Prior to this study, only general flood plain information was available. This study provides detailed information regarding flood elevations and floodway requirements so that sound flood plain management options can be formulated.

Park County will use this information to meet state and federal requirements regarding flood plain management. The State of Montana will use this study to establish official flood plain and floodway boundaries as stated in the Montana Floodway Management and Regulations Act.

The information in this study will also be used by local residents to assess the need for flood insurance, floodproofing, or other actions.

Contributing Agencies

Personnel from Park County and the MDNRC assisted the Soil Conservation Service in the field surveys and other phases of this study. Data were provided by the U.S. Geological Survey, the Montana Department of Highways, and local residents.

Study Sponsors

The request for a study was made in accordance with the Joint Coordination Agreement between DNRC and the Soil Conservation Service (SCS) that was signed June 20, 1975, and revised March 16, 1979.

A cooperative plan of study for the Shields River Flood Plain Management Study was prepared and signed by DNRC, Park County, Park Conservation District, and SCS in November 1989. This study was authorized by the Chief of the Soil Conservation Service on February 15, 1990.

Study Authority

This study was conducted under authority of Public Law 83-566, Section 6, Flood Plain Management Assistance Program. This program allows SCS to assist state and local agencies perform flood plain management studies.

In addition, the 1971 Montana legislature passed the Montana Flood Management and Regulation Act, title 89, chapter 35, Revised Code of Montana. This Act was revised by the 1973 and 1974 legislatures. It authorized the Montana Department of Natural Resources and Conservation to initiate a comprehensive program of floodway delineation and regulation for the entire state. See appendix I for a copy of the complete regulations.

STUDY AREA DESCRIPTION

Location

The study reach involves about 23 miles of the Shields River stream channel from near Wilsall to its mouth at the Yellowstone River and about 0.5 miles of Flathead Creek in Park County, Montana.

The Shields River heads in the Crazy Mountains about 40 miles north of Livingston, Montana. It runs south past the communities of Wilsall and Clyde Park and enters the Yellowstone River about 5 miles northeast of Livingston. (See attached map). Clyde Park is an incorporated community of about 283 people. Wilsall is unincorporated and has a population of about 200.

The drainage area of the Shields River at Wilsall is 185 square miles. At Clyde Park, the drainage area is 543 square miles and at the mouth of stream it is 856 square miles. The drainage area is mostly rangeland but includes areas of forested mountains, and some cropland. The study area lies within USGS Hydrologic Unit No. 10070003.

The limits of study for the Shields River were from its confluence with the Yellowstone River in Section 26, T1S, R10E, to the north line of Section 30, T3N, R9E, 1 mile east of Wilsall, Montana. The study reaches were studied in a detailed intensity level due to the existing and potential future development.

Land Use and Vegetation

About 18 percent of the drainage area is considered forested. About 30 percent of the forested land is commercial forest suitable for timber harvest. About 5 percent of the drainage is in dry cropland and about 6 percent is irrigated cropland. The remainder of the area, about 71 percent, is classified as rangeland (Ref 1).

The vegetation along the Shields River south of Wilsall is comprised of a dominant overstory of black cottonwood. The understory is primarily willows, alder, dogwood, and water birch with an understory of grasses and sedges. The broader areas of the flood plain are used for irrigated hay and pastureland, and sometimes these areas go right up to the rivers edge.

Soils

The soils in the Shields River watershed are formed in mixed volcanic sediments throughout the valley and in glacial outwash and alluvium from the Crazy Mountains. The volcanic sediments are mainly from the Livingston Group of upper Cretaceous age. They include volcanic sandstone, siltstone, mudstone, and welded tuff. These typically form fine to medium textured soils underlain by soft and hard bedrock at depths of 10 to 40 inches. Representative soil series are Cabba, Regent, and Tolman. The Tamaneen series is found on lower positions above the flood plain. It is formed in calcareous alluvium and is fine textured and well drained.

Soils in the terraces surrounding the Crazy Mountains are generally high in clay content and coarse fragments and include the Fergus and Roy series.

The soils in the Shields River flood plain are nearly level to gently sloping. Some of the more common soils are the Meadowcreek, Nesda, Soapcreek, and Havrelon series, and the subgroup Fluvaquentic Haplaquolls. Havrelon soils are well drained; Meadowcreek and Soapcreek soils are somewhat poorly drained; and Fluvaquentic Haplaquolls are poorly drained. Nesda, Soapcreek and Meadowcreek soils allow a fluctuating water table from 3 to 6 feet. Meadowcreek soils are underlain by sand and gravel at depths of 20 to 40 inches; Nesda soils have sand and gravel near the surface; and Soapcreek and Havrelon are deep, fine to medium textured soils.

Meadowcreek soils are moderately permeable to about 2 feet and very rapidly permeable below. Nesda soils have rapid permeability throughout. Soapcreek soils are slowly permeable. Water-holding capacities are low for Nesda; medium for Meadowcreek; and high for Soapcreek and Havrelon. Fluvaquentic Haplaquolls have variable permeability and water-holding capacity.

Major management concerns for these flood plain soils include a rare to occasional flood hazard, high water tables, and areas with shallow depths to sand and gravel (Ref 2).

Climate

The climate of the watershed is characterized by warm summers and cold winters. Precipitation, and to a lesser extent, temperatures in the area are highly dependent on elevation which varies over the watershed from 4,375 feet at the Yellowstone River to nearly 11,000 feet in the Crazy Mountains. The average annual precipitation at the Livingston Airport, the nearest long-term weather station, is 15.12 inches (Ref 3). Short term records near Clyde Park and Wilsall indicate that the precipitation in the Shields Valley is in the 13 to 15-inch range. The Bridger Mountains to the west with elevations over 9,000 feet have an annual precipitation of over 50 inches, and the Crazy Mountains on the east have an annual precipitation of over 60 inches (Ref 4).

The mean annual temperature at the Livingston Airport station is 44.7 ° F, and at Wilsall is 40.8° F. The warmest month is July with a mean temperature of 59.3° F at Livingston. The coldest month is January with a mean temperature of 23.7° F. The average 28° F frost-free period is from May 7 to October 4, a 150-day period. About 70 percent of the annual precipitation falls in the April through September period (Ref 3).

NATURAL FLOOD PLAIN VALUES

Wildlife populations are important resources in the Shields Valley. Wildlife values should enter into land management and development planning. Wildlife related recreation (hunting and wildlife viewing) is very important to this area. Healthy wildlife populations help make the Shields more attractive to people, both residents and tourists alike.

Moose use the Upper Shields River north of Elk Creek as summer range and to some extent as winter range. Cow moose raise their calves in thick willow bottoms, marshy side channels and in hay meadows during the summer. They are watched with considerable interest by local landowners who enjoy seeing and protecting them. An occasional moose is seen wandering through lower stretches of the river or in the headwaters of major tributaries.

White-tailed deer numbers are increasing in the Shields. There are more whitetails on the Shields than anywhere else in Park County. They thrive in dense river bottom vegetation adjacent to agricultural fields (particularly hay meadows).

Sandhill crane populations in the Shields Valley have increased dramatically in the past 5 years. The number of nesting pairs and amount of use during migration have both increased. Sandhill nesting occurs on or near flood plain areas, typically on wet sites or in fields adjacent to wet areas. Adults and young feed in agricultural fields and in wetland sites along the river.

Increasing numbers of Canadian geese are nesting on the Shields River every year. They depend to a large extent on flood plain areas for secure nesting sites and brood rearing areas. Geese also use agricultural areas for feeding.

Bald eagle use along the Shields is increasing. Migratory eagles are using the river more and more each year. They are relatively common in winter and spring, feeding along the river and also on carrion some distance from water. There are patches of suitable mature cottonwood in the valley that would make good nesting sites. It appears likely that the recovering bald eagle population will eventually nest on the Shields.

A number of "puddle duck" species, including mallards, green-wing teal, cinnamon teal, American widgeon, and gadwall nest on or near the Shields River. Thick vegetation and slow moving water stretches or side channels provide good nesting and brood rearing habitat.

Beaver, mink, muskrat and otter are found along the Shields River. Thick riparian vegeation and an adequate prey base will insure good population of these species.

Great blue herons are common along the Shields River. Their communal nesting areas (typically in cottonwoods) should be protected when possible. There is an unconfirmed double crested cormorant rookery on Antelope Creek north of Clyde Park. These birds are relatively rare and nesting sites should be protected when possible.

There is limited pheasant production in a few flood plain areas along the Shields and its tributaries. Pheasants depend on a blend of thick winter cover, agricultural crops and adequate nesting habitat to survive.

The Shields River flood plain support an abundance of nongame birds. A wide variety of species nest in the riparian habitat including several species of warblers, flycatchers, sparrows, wrens, raptors, blackbirds, kingfishers, and wading birds.

The Shields River provides a fair to good fishery with brown trout dominating the catch at the present time. Rainbow trout are present primarily below the Chadburn diversion. It appears some brown and rainbow trout from the Yellowstone River use the lower Shields River below the Chadburn diversion for spawning. Fish habitat in the main stem, particularly below Wilsall, is fair to poor, but could be improved with good management practices.

The Shields also supports populations of Yellowstone cutthroat trout, a native species designated as a "species special concern" in Montana. Cutthroats are more abundant in the headwater portion of the main stem and its tributaries. The upper Shields River basin appears to be one of the last strongholds for the native Yellowstone cutthroat trout outside of Yellowstone National Park.

All of the above-mentioned wildlife species depend to one extent or another on healthy riparian or flood plain habitats. Poorly planned human development (subdivisions, agriculture, and grazing) of these areas could have a negative impact on important wildlife resources. The Shields Valley's low human population and relatively low impact agriculture has fostered excellent wildlife populations that are enjoyed by many people. Careful land management planning for the future will preserve the valley and all of its resources.

Cultural Resources

Because of the diverse natural resources in the Shields River Valley, the valley contains rich and diverse cultural resources as well.

Fossilized remains of prehistoric bison and woolly mammoth can be found at various locations in the watershed. One of the most important archaeological sites in North America exists at the confluence of Flathead Creek with the Shields River, the Mel Ansick site, a cache site for prehistoric man. Man has used this valley for some 12,000 years. The stream course was especially favored by prehistoric man.

Historic resources are also present, such as Clark's old fort at the mouth of the Shields. Clark constructed this fort in 1806 on his return trip from the west coast. The Bridger trail also made its way through the area over Flathead Pass.

FLOOD PROBLEMS

Flood History

Major floods on the Shields River occurred in 1943, 1948, 1979, and 1981. The 1948 flood was the largest recorded event and was approximately a 50 to 75 year event. The flood occurred on June 5, and was the result of heavy rains which caused flooding in many streams in the region. The Shields River had already flooded on May 22, and damages from that event were reported by the Livingston Enterprise as in the high thousands. Damages included farm equipment and vehicles that were swept into the stream (Ref 5).

The second largest flood of record occurred on March 30, 1943. That flood resulted from a rapid snowmelt. The early thaw came after a heavier than normal snowpack. One home was reported as being in danger of being swept away. Several families evacuated their homes and moved livestock to higher ground but some livestock were lost (Ref 6).

The flood of June 20, 1979, was between a 30 and 50-year event. The flooding caused considerable damage to fields along the river and closed seven bridges on county and private roads. The flood was a result of widespread heavy rains. At Wilsall a total of 4.7 inches fell in a two-day reporting period. At Clyde Park, 4.43 inches were reported in a 24-hour period by a local observer (Ref 7).

Present Flood Potential

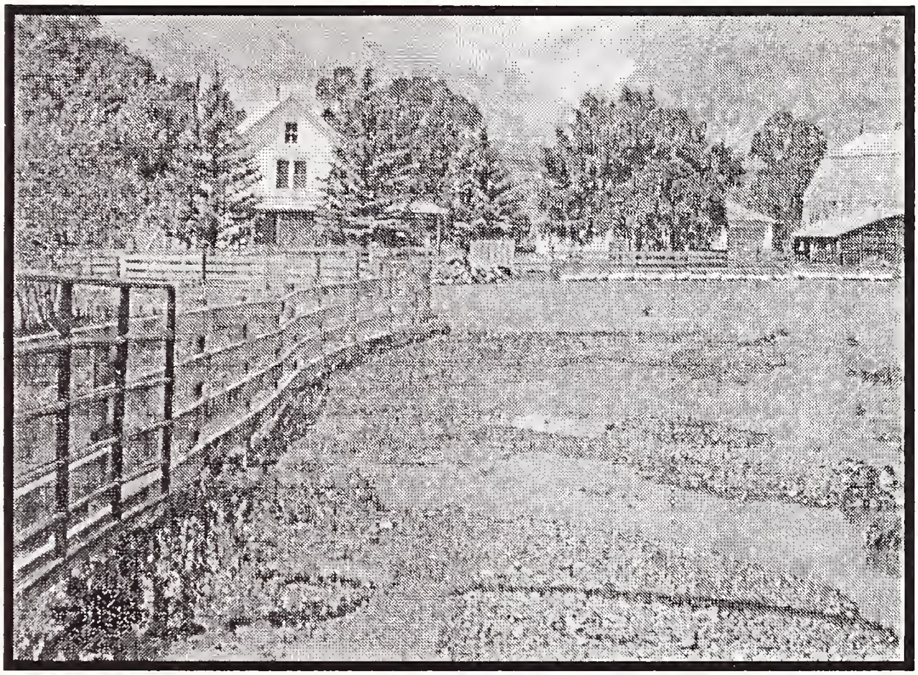
Minor flooding occurs on the Shields River on the average once in 5 years. Damage during a 5-year flood is mostly to low-lying agricultural land and some roads and improvements near the stream channel. Streambank erosion is prevalant during a 5-year or larger flood event.

Significant damages will occur during floods which can be expected once in 25 years or less. The floods described above fit this category. The 100-year flood would damage eight homes in the study reach. Fifteen homes would be damaged in a 500-year flood. As with past floods, road and bridge damage would be significant and road closures would be expected.

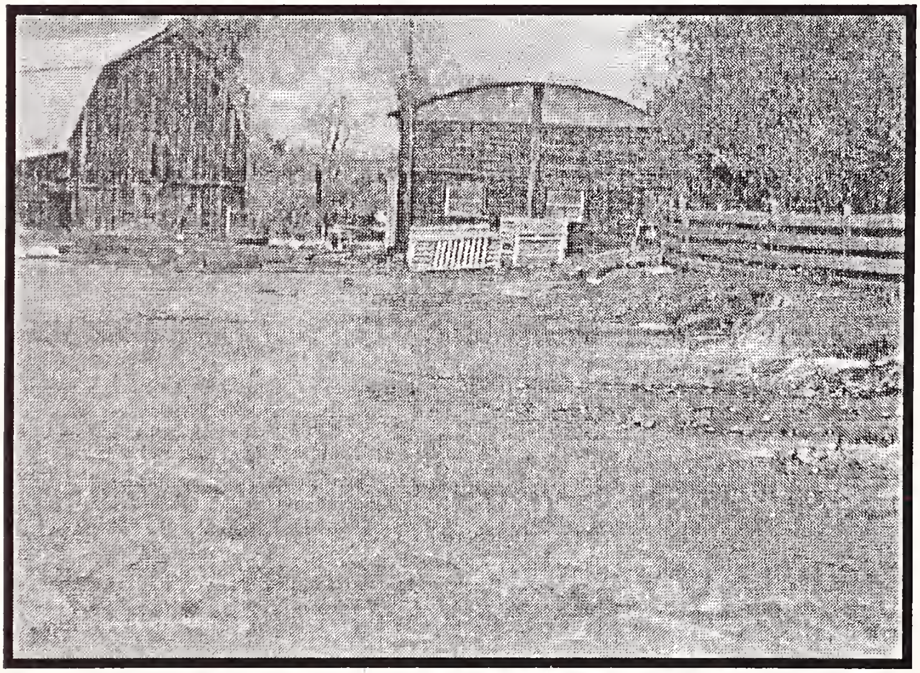
Future Flood Potential

Peak discharges are not expected to change significantly in the future. Little change in land use is expected in the watershed which could change runoff potential. Timber harvesting, fires, and other events do not normally affect a large enough area to have a large impact on flooding potential.

PHOTO PLATE 1



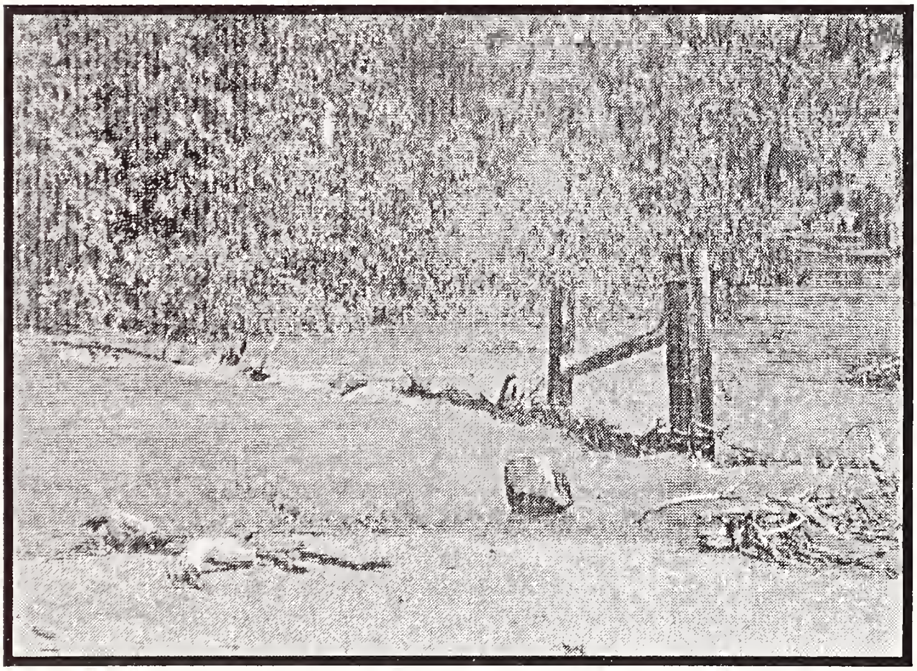
Flood water through farm yard near the Shields River during June 1992 flood (note the sandbags protecting the house).



The flood water was diverted from an abandoned meander loop of the Shields River by a beaver dam.

PHOTO PLATE 2

Flood water over a county road along the Shields River during June 1992.



This flow is alongside Highway 89 between Clyde Park and Livingston in June 1992.

Development in the flood plain, which may obstruct the channel or flood plain, may have a significant effect on flooding depths. Any development which is proposed, including improved roads, should be evaluated for the effect it may have on increasing the flood potential in the area.

FLOOD PLAIN MANAGEMENT

Existing Programs and Measures

The Park County Commissioners have adopted flood plain regulations in accordance with Montana Law which allows the county to participate in the National Flood Insurance Program. This program is administered by the Federal Emergency Management Agency which makes flood insurance available to cities and counties participating in the program. It provides flood insurance at subsidized rates to owners and occupants of all buildings and mobile homes and their contents. The regulations adopted by the county require a flood plain development permit for new construction and substantial improvements occurring in flood prone areas.

It is recommended that buildings and mobile homes within or adjacent to delineated flood plain areas carry flood insurance.

Management Alternatives

A program of sensible land use regulations to keep future development out of flood prone areas identified by this study, appears to be the best way to manage the Shields River. The Montana Flood Plain Law (Appendix I), provides the means to accomplish this. This law calls for restrictive land use within identified flood plain areas. The law is structured around the concept of floodway and flood fringe areas within the 100-year flood plain. Different restrictions apply to these areas and allow for some flexibility in regulation of flood plain areas.

The floodway concept was devised to provide some indication of how new encroachments on flood plain areas such as buildings and landfills will increase flood depths in that area.

A floodway is defined as a smaller area within the existing 100-year flood plain in which the floodwater could be restricted while limiting the resulting increase in flood depths to some specified value. In other words, the floodway boundary at any point is computed by placing imaginary walls on each side of the flood plain which can contain the entire flood flow between them. As these walls are squeezed together, the water surface increases in depth. A computer program is used to compute how much these walls must be moved together to achieve some given increase in depth. The computed location of these walls defines the floodway boundaries. The maximum increase in depth allowed by Montana Law (Appendix I) for the floodway is one-half (.5) foot for the 100-year flood. The area between the actual 100-year flood plain boundaries and the floodway boundaries is called flood fringe area. Montana law officially refers to the two areas as the designated floodway and the flood plain fringe.

Basically, Montana law provides for many land uses as being compatible with periodic flooding and these are permitted in the designated floodway. Some of these uses include agricultural uses, industrial and commercial loading or parking areas and open-type recreation areas. Buildings for living purposes or commercial structures are not allowed in the designated floodway. However, buildings are allowed in the flood plain fringe areas if their lowest floor is elevated 2 feet above the 100-year flood elevation.

Flood prone areas along the Shields River could be designated as greenways, parks, agricultural use, wetlands, or as a buffer zone through zoning regulations.

Some homes and farmsteads could be protected with dikes and levees. Channel modifications and development which restricts the flood plain should be avoided unless carefully studied as to their possible consequences. Floodproofing of existing buildings could also be considered; such as raising foundations, installing watertight seals on doors and windows, and installing valves on sewer lines to prevent backup, among other things.

Channel vegetation should be protected and maintained to increase stability and reduce erosion. Management of the riparian zone could reduce streambank erosion and damage to adjacent fields.

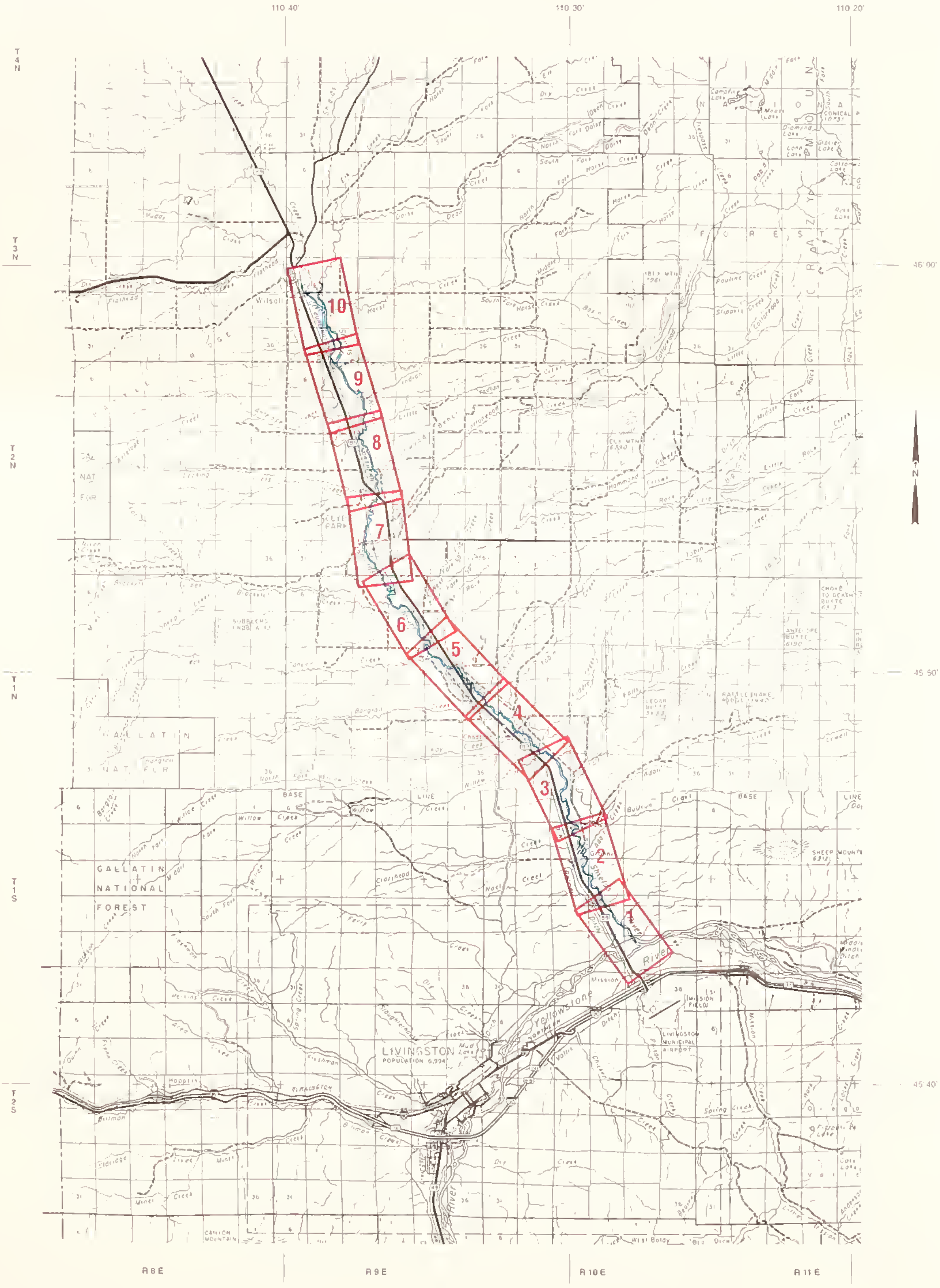
A public information program should be initiated to encourage all those identified as living in the flood plain to purchase flood insurance. Actually, anyone living anywhere in Park County who considers themselves in danger of being damaged by flooding can purchase flood insurance.

APPENDIX A

FLOOD HAZARD MAPS

U S DEPARTMENT OF AGRICULTURE

SOIL CONSERVATION SERVICE

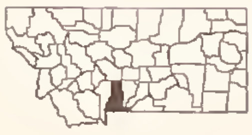


LEGEND

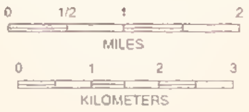
10 SHEET COVERAGE

~ STREAM REACH STUDIED

INDEX TO MAP SHEETS
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA



VICINITY MAP



SOURCE
COMPILED FROM 1988 GENERAL HIGHWAY MAP AND
INFORMATION FROM SCS FIELD PERSONNEL
POLYCONIC PROJECTION

MARCH 1993 1007650-01

USDA, SCS, NATIONAL CARTOGRAPHY & GIS CENTER, FORT WORTH, TX, 1993

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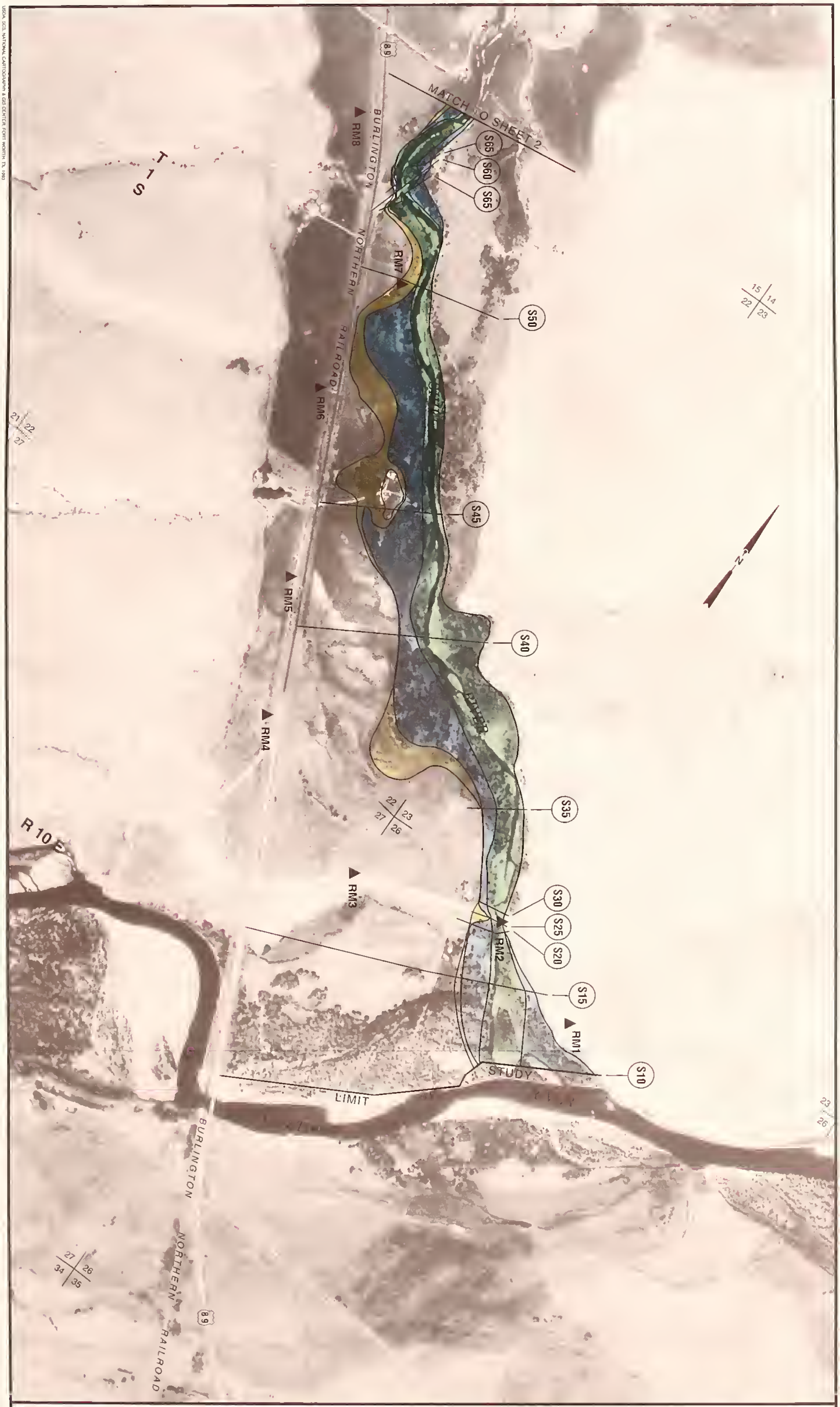

LEGEND

🟩 100-Year Floodway

🟦 100-Year Flood Hazard Area

🟨 500-Year Flood Hazard Area

(S10) Valley Section Location

▲ Reference Marks

NOTE
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

0 800 1600
APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

SHEET 1 OF 10

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SHEILDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

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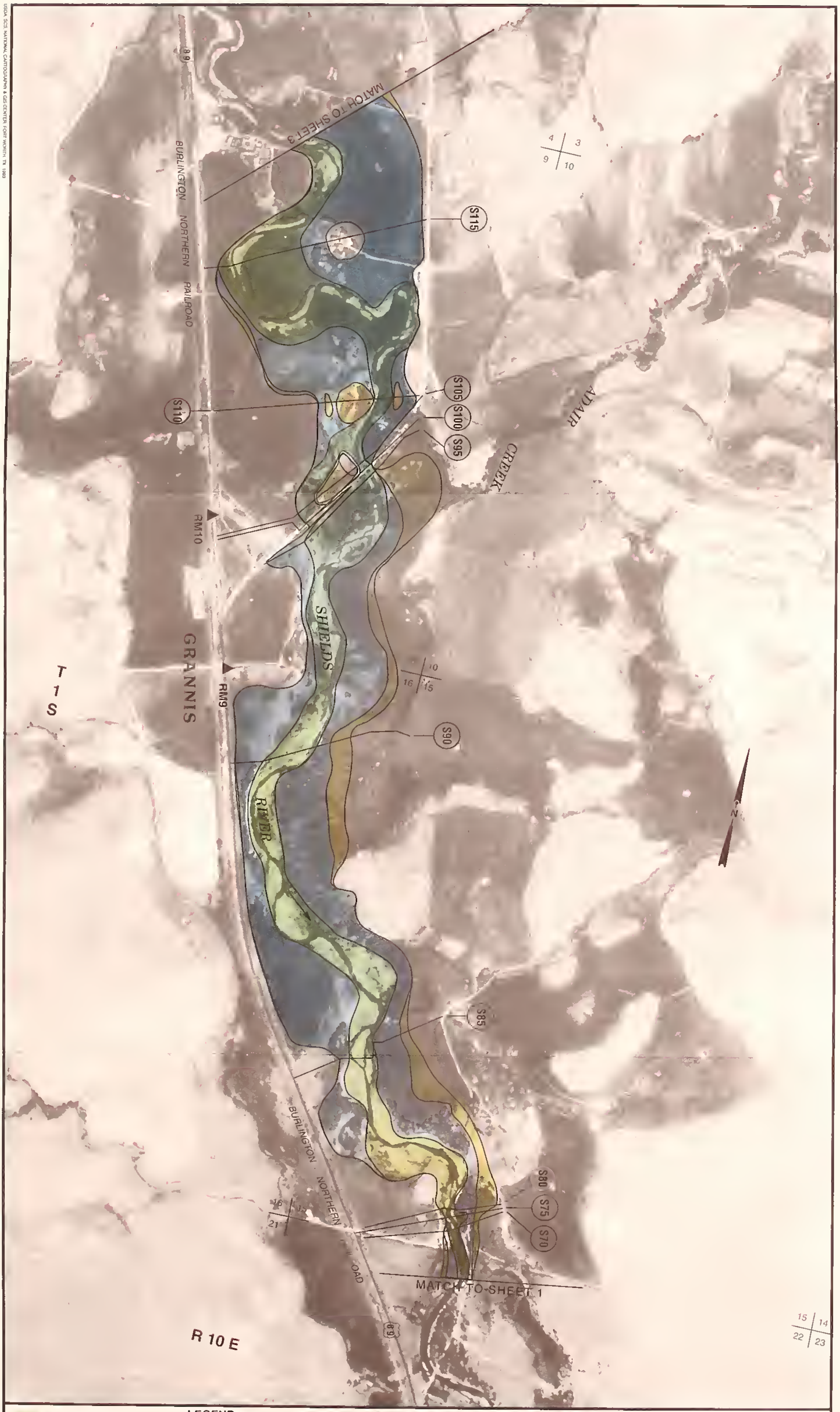

LEGEND

🟩 100-Year Floodway
🟦 100-Year Flood Hazard Area
🟨 500-Year Flood Hazard Area

(S70) Valley Section Location
▲ Reference Marks

NOTE.
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0 800 1600
APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

SHEET 2 OF 10

U.S. DEPARTMENT OF AGRICULTURE
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SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

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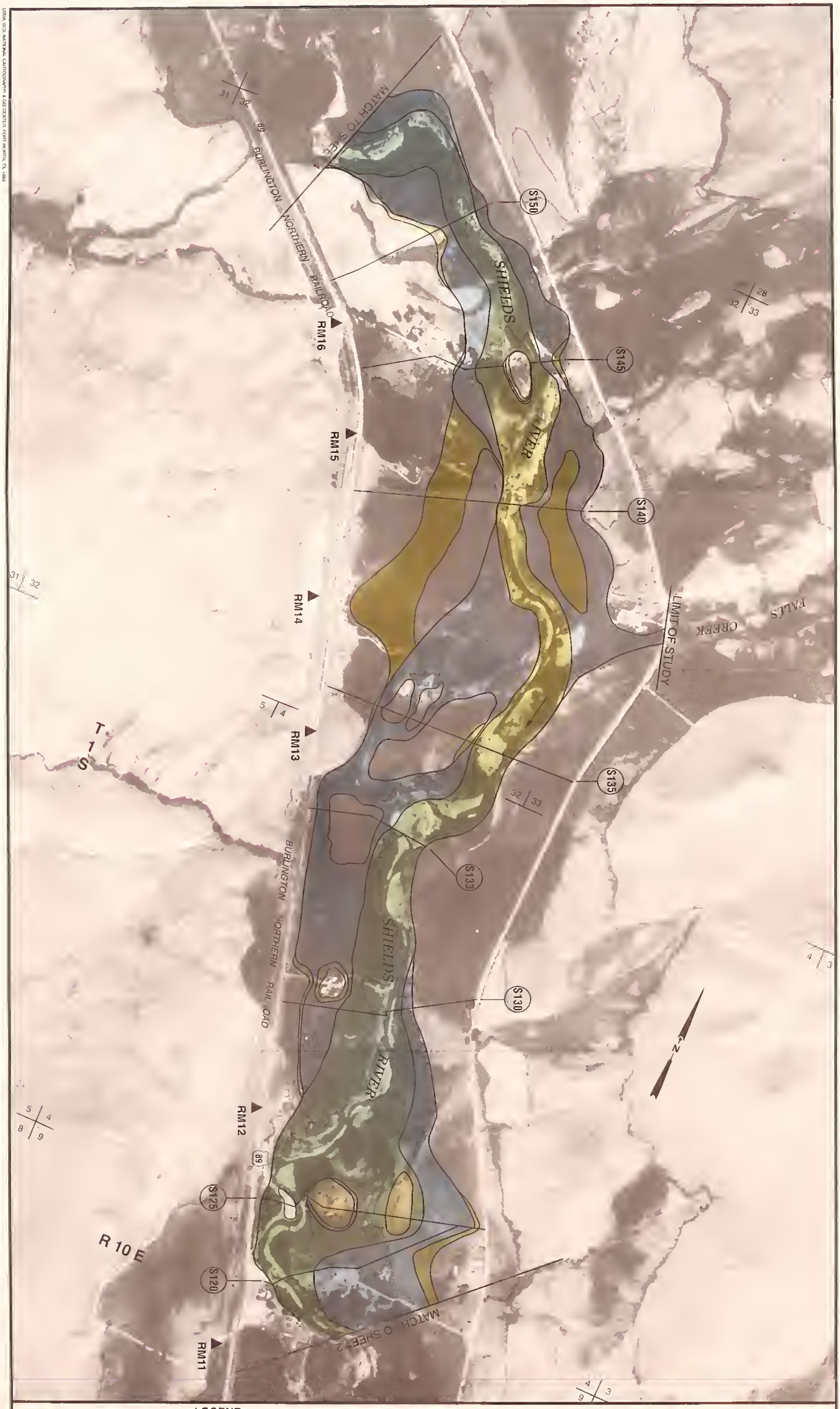

LEGEND

🟩	100-Year Floodway
▨	100-Year Flood Hazard Area
🟨	500-Year Flood Hazard Area
(S120)——	Valley Section Location
▲	Reference Marks

NOTE
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APPROXIMATE SCALE IN FEET

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SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

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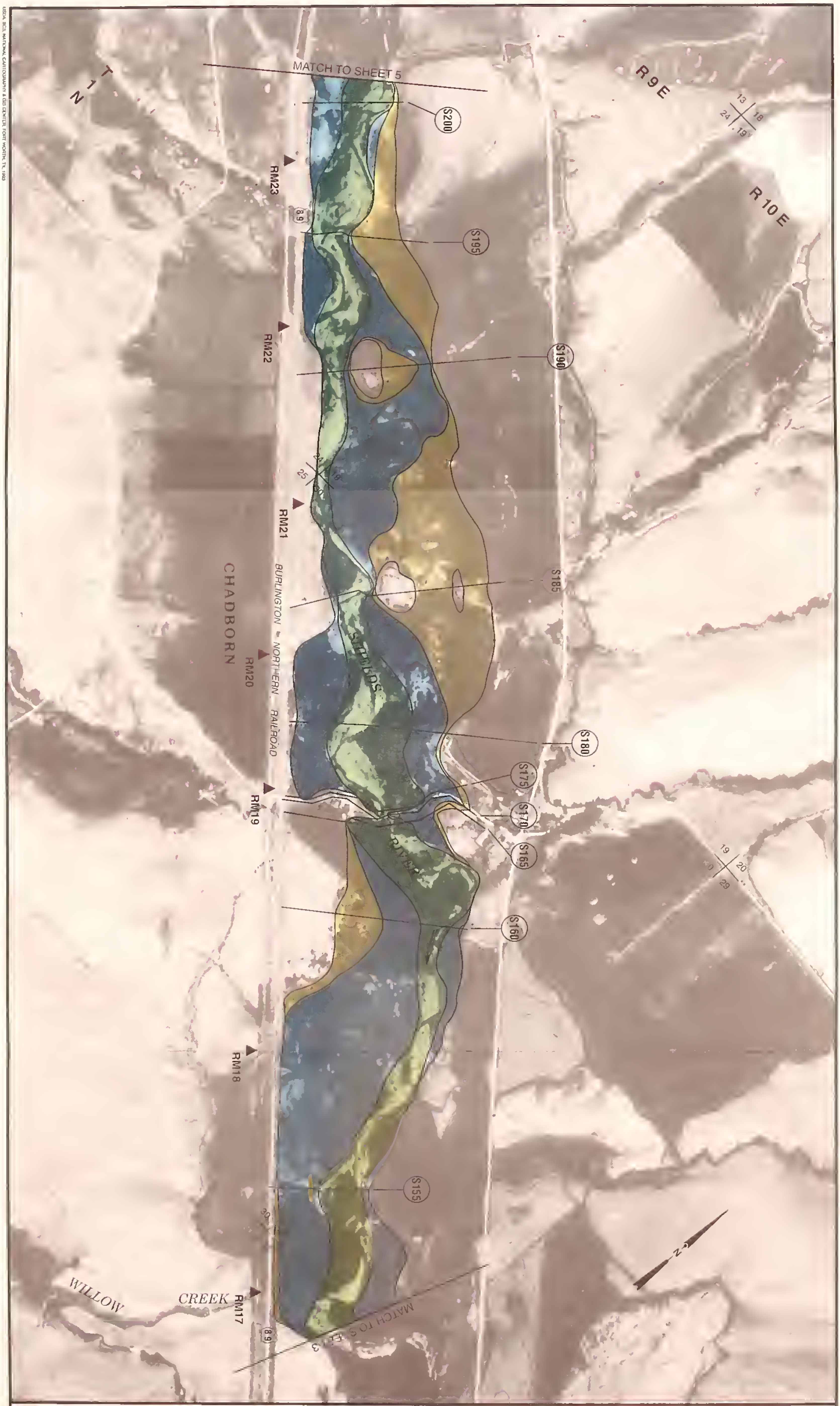

LEGEND

🟩	100-Year Floodway
🟦	100-Year Flood Hazard Area
🟨	500-Year Flood Hazard Area
(S155)	Valley Section Location
▲	Reference Marks

NOTE
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

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APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

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SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

SHEET 4 OF 10

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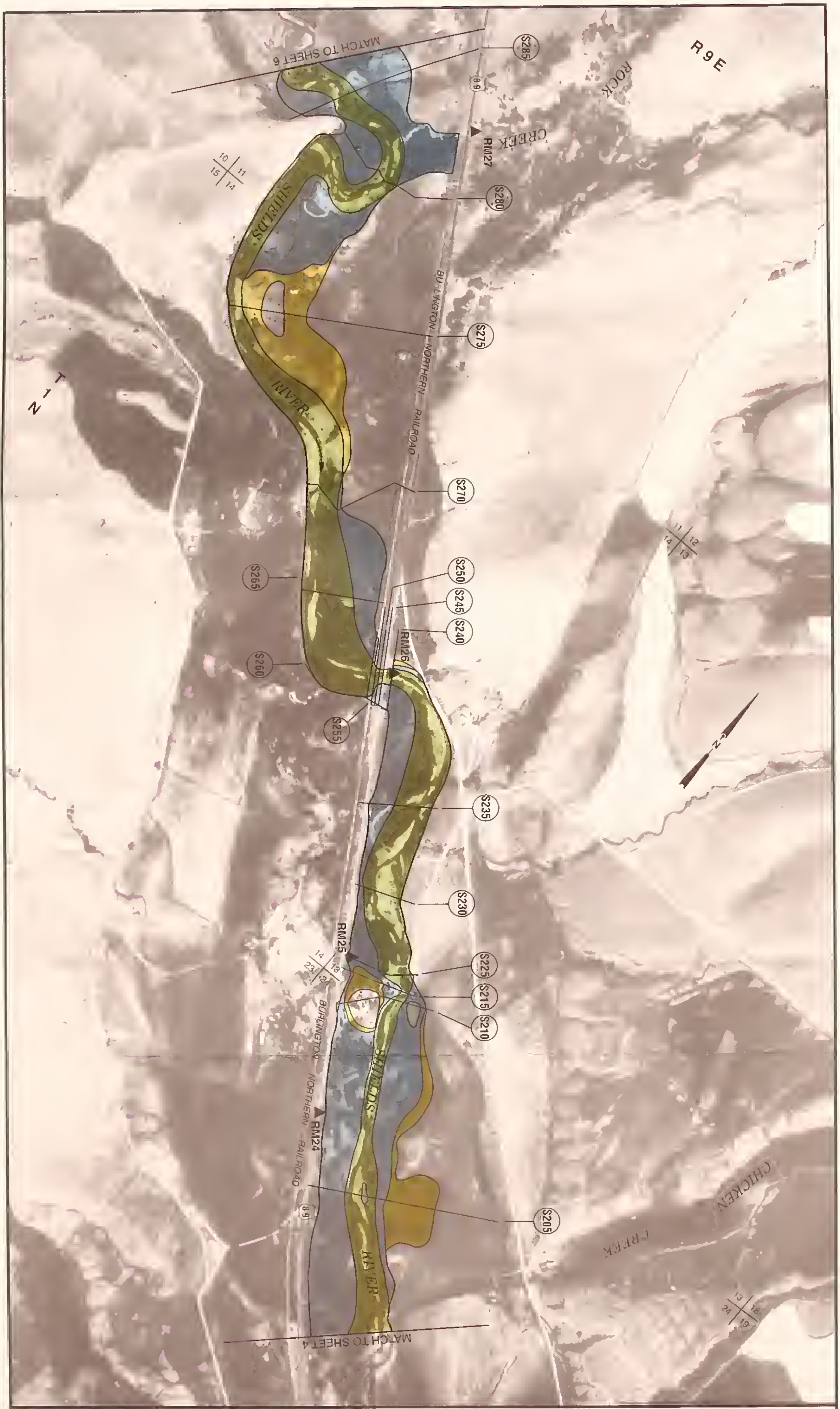

LEGEND

- 🟩 100-Year Floodway
- ▨ 100-Year Flood Hazard Area
- 🟨 500-Year Flood Hazard Area

(S205) Valley Section Location

▲ Reference Marks

NOTE
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

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APPROXIMATE SCALE IN FEET

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FLOOD HAZARD AREA

SHIELDS RIVER

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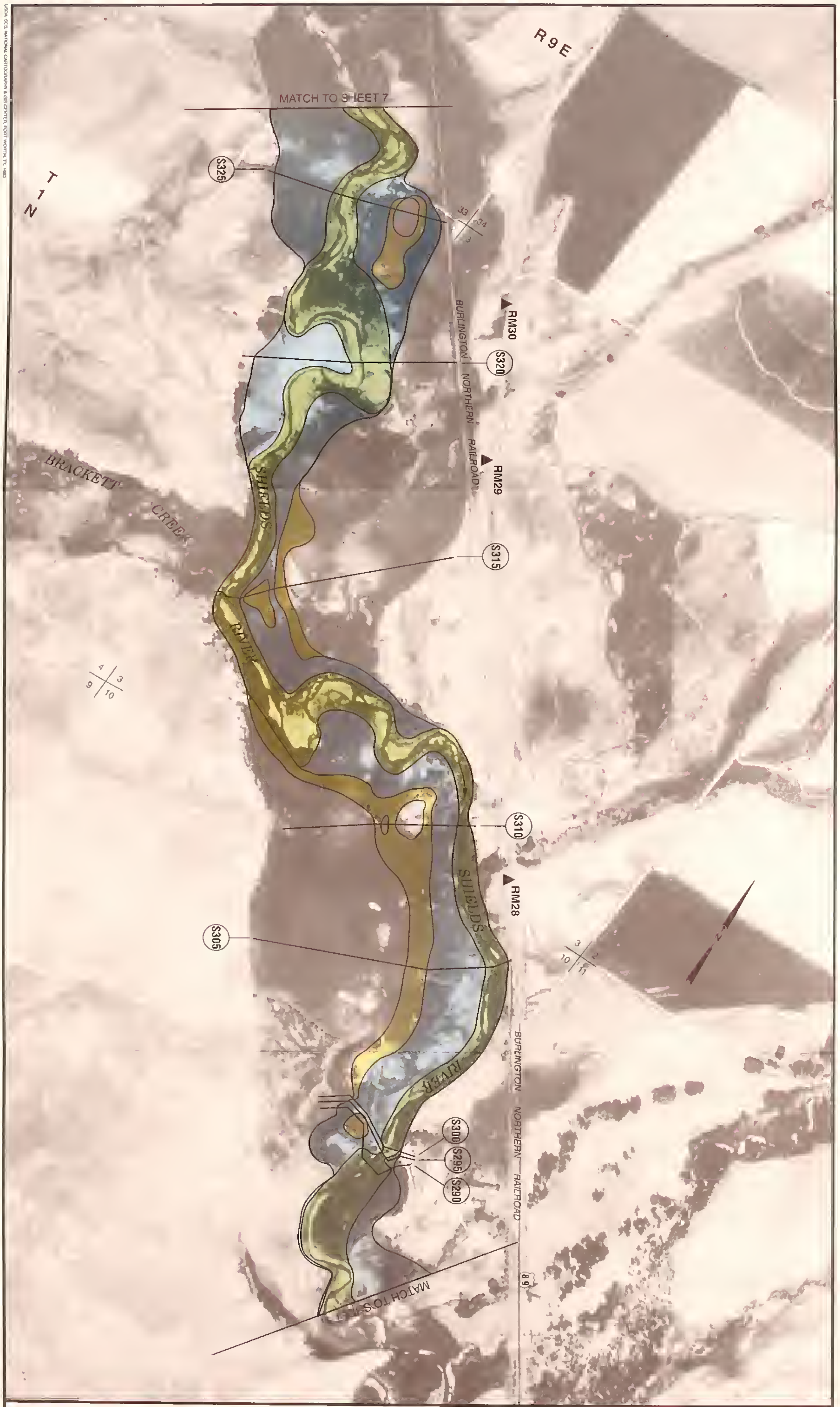

LEGEND

🟩	100-Year Floodway
🟦	100-Year Flood Hazard Area
🟨	500-Year Flood Hazard Area
(S290)—	Valley Section Location
▲	Reference Marks

NOTE
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT. THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

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APPROXIMATE SCALE IN FEET

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FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

SHEET 6 OF 10

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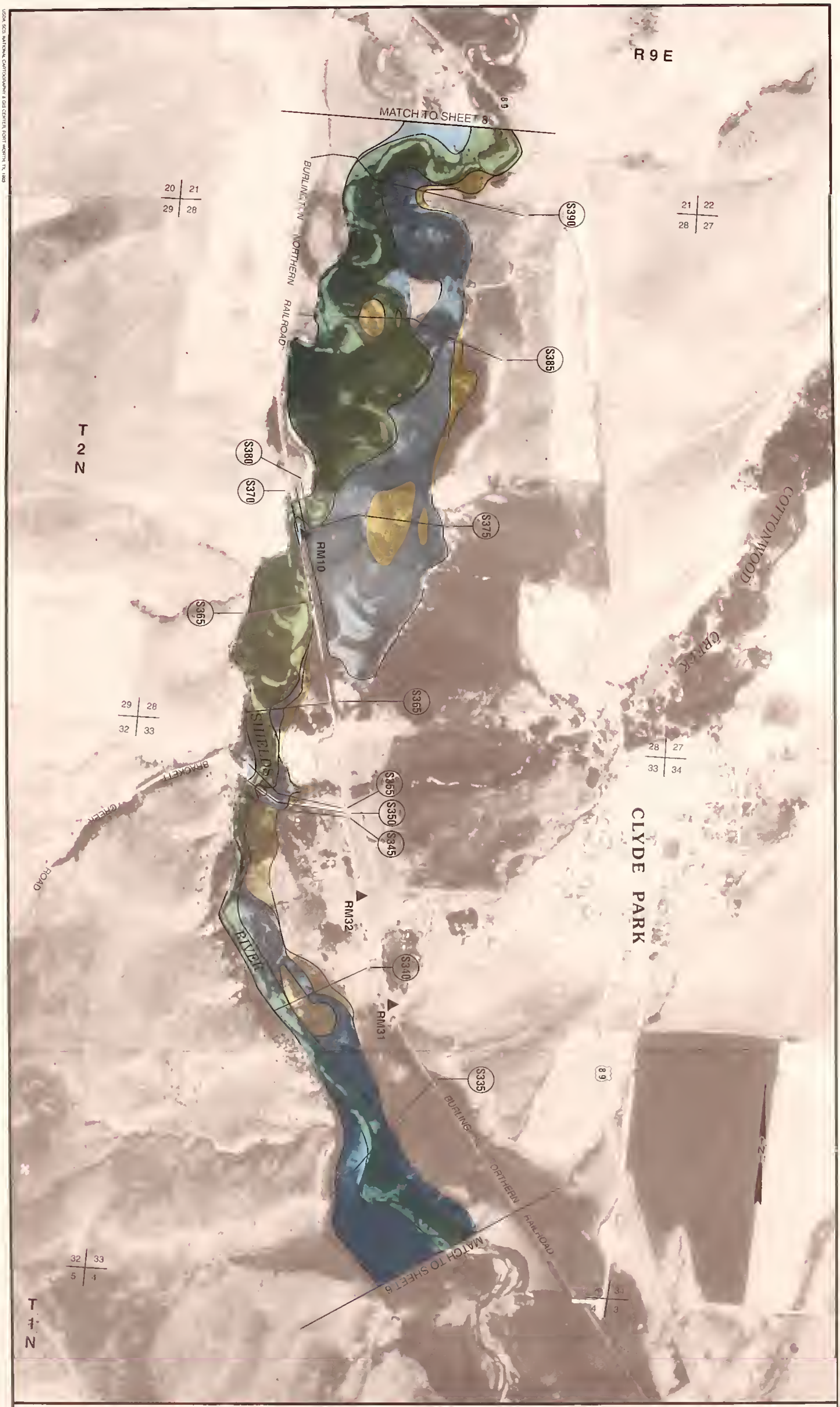

LEGEND

🟩	100-Year Floodway
🟦	100-Year Flood Hazard Area
🟨	500-Year Flood Hazard Area
S335	Valley Section Location
▲	Reference Marks

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

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FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

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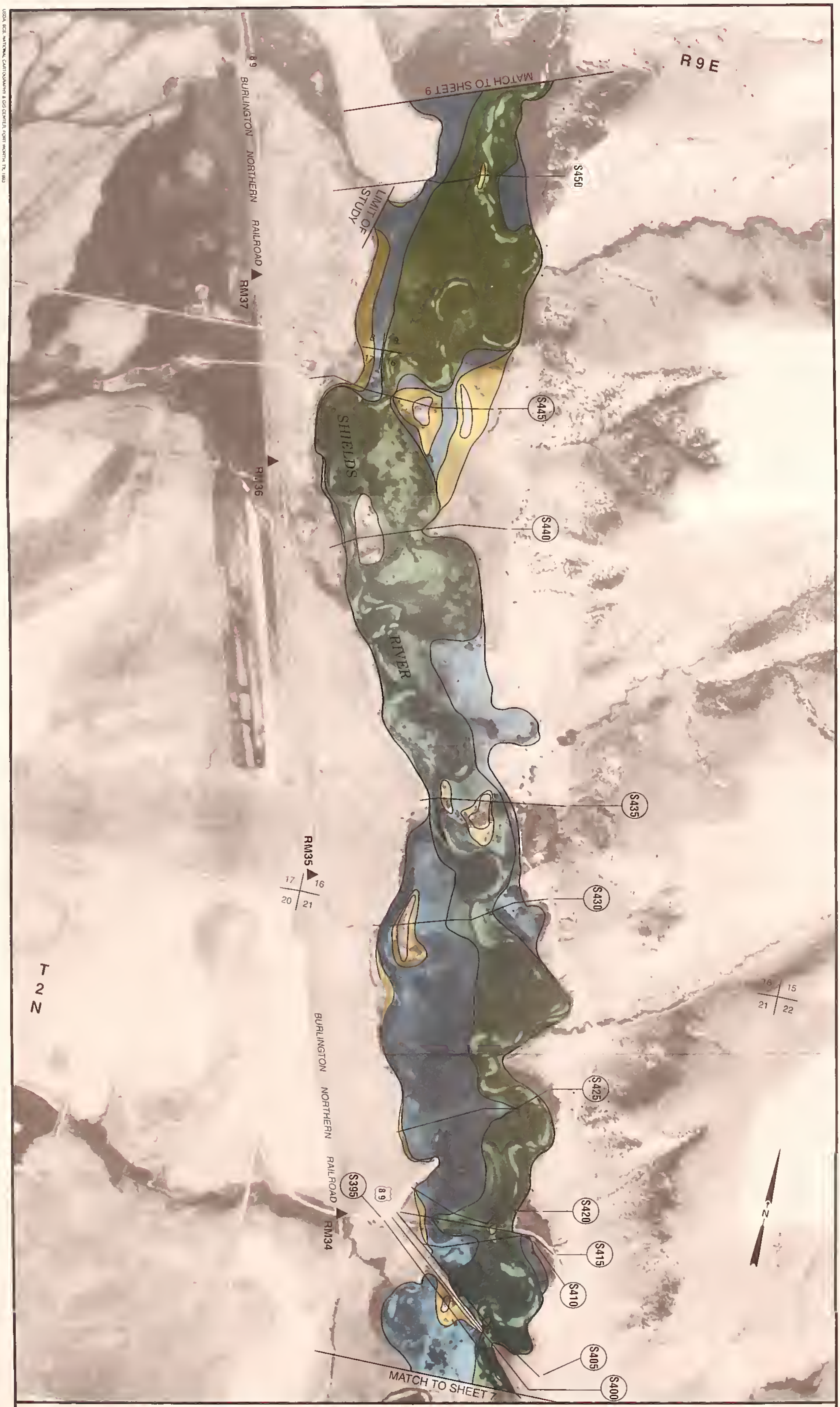
JUNE 1992 1007650

USDA SCS NATIONAL CARTOGRAPHY & GIS CENTER, FORT WORTH, TX 1993



LEGEND

🟩	100-Year Floodway
🟦	100-Year Flood Hazard Area
🟨	500-Year Flood Hazard Area
(S395)	Valley Section Location
▲	Reference Marks

NOTE:
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

0 800 1600
APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

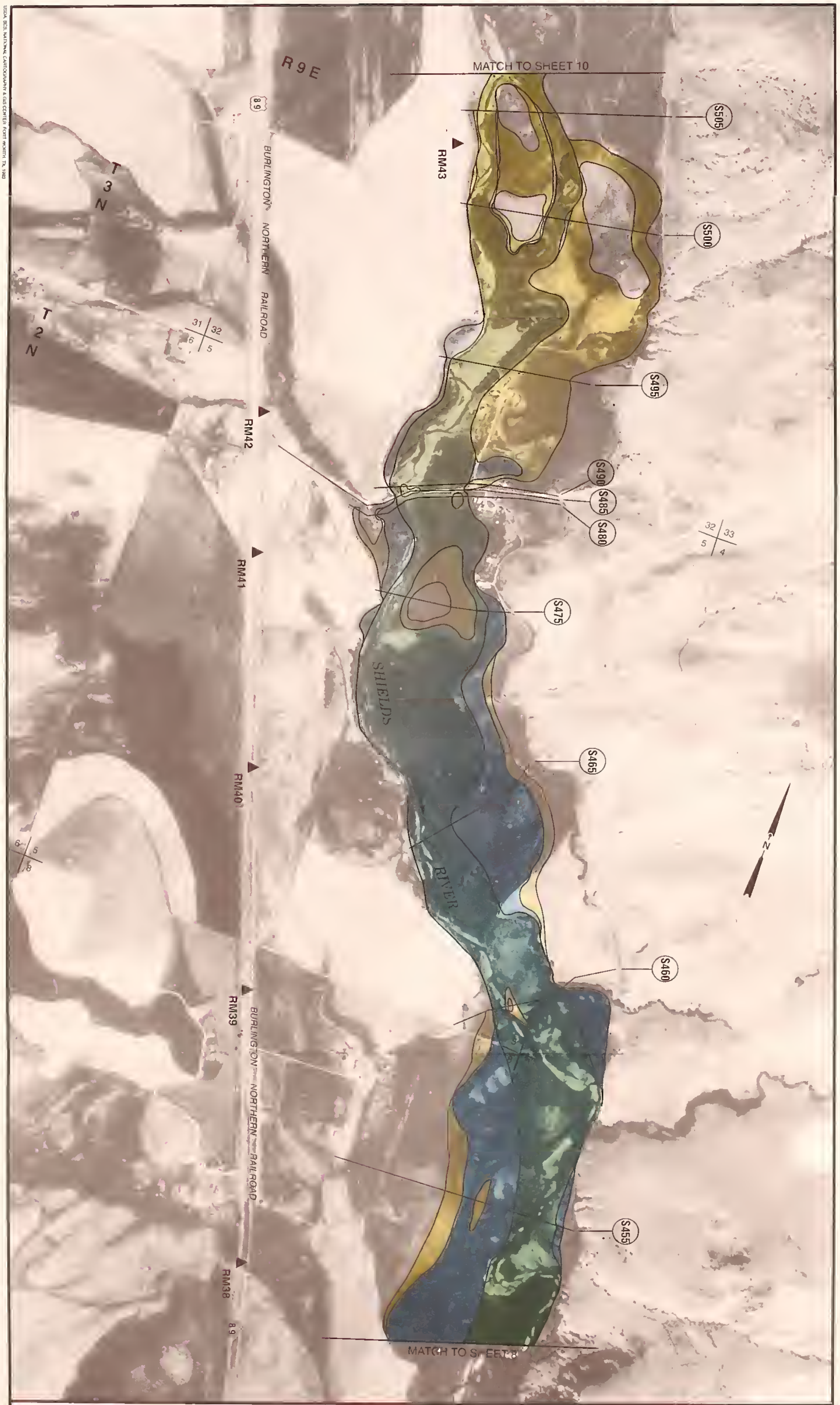
SHEET 8 OF 10

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

JUNE 1992 1007650



LEGEND

🟩 100-Year Floodway

🟦 100-Year Flood Hazard Area

🟨 500-Year Flood Hazard Area

(S455) Valley Section Location

▲ Reference Marks

NOTE.
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION.

0 800 1600
APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

U.S. DEPARTMENT OF AGRICULTURE
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SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

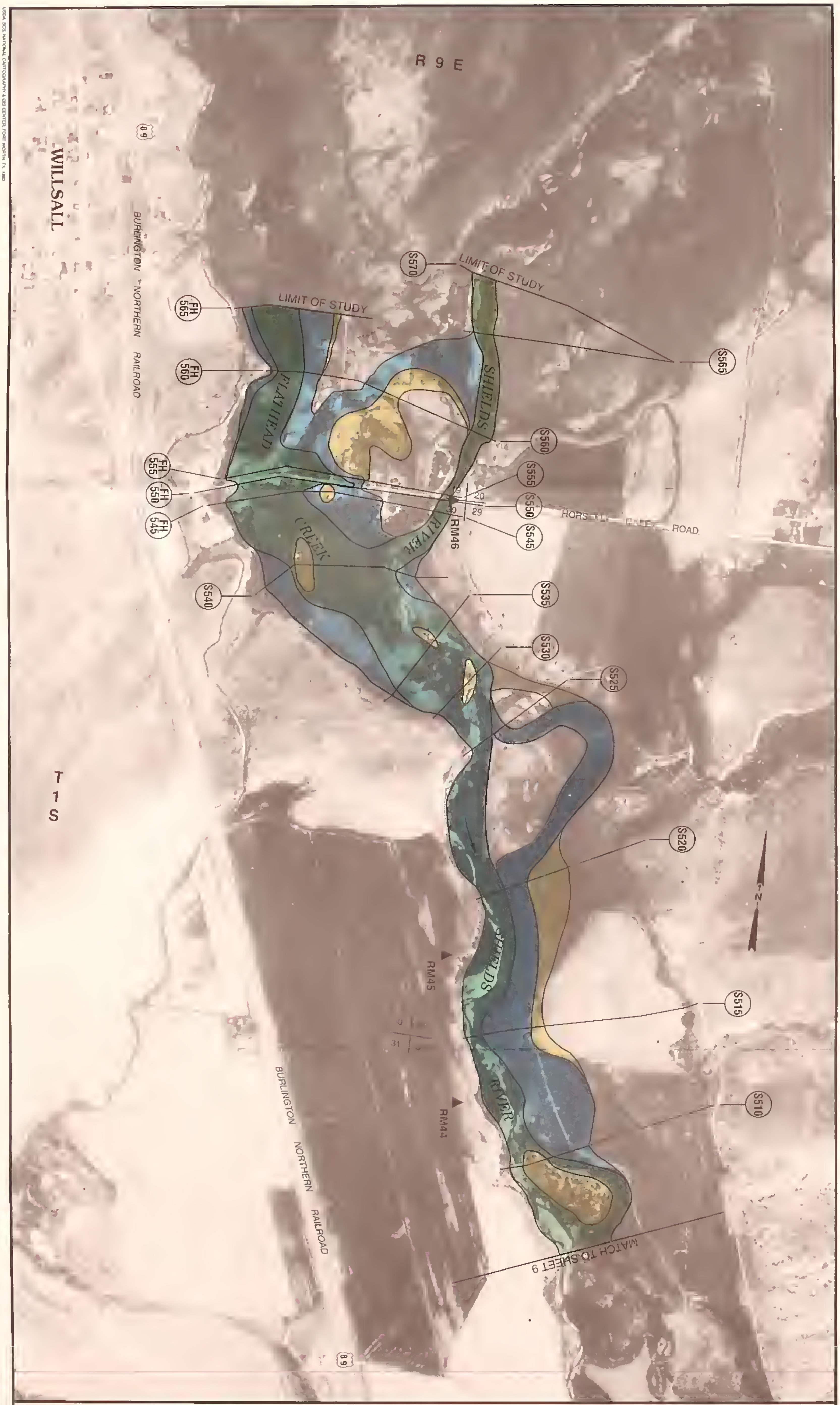
FLOOD HAZARD AREA

SHIELDS RIVER

JUNE 1992 1007650

USDA SCS NATIONAL CARTOGRAPHIC & GIS CENTER FORT WORTH, TX 1992

USDA SCS NATIONAL CARTOGRAPHY & GIS CENTER FORT WORTH TX 1992



LEGEND

🟩 100-Year Floodway

🟦 100-Year Flood Hazard Area

🟨 500-Year Flood Hazard Area

(S510)—— Valley Section Location

▲ Reference Marks

NOTE
LIMITS OF FLOODING SHOWN MAY VARY FROM ACTUAL LOCATIONS ON THE GROUND AND DUE TO INHERENT AERIAL PHOTOGRAPHIC DISPLACEMENT THE PHOTOGRAPHIC IMAGE MAY VARY FROM TRUE GROUND LOCATION

0 800 1600
APPROXIMATE SCALE IN FEET

1977 USGS Ortho Photography

JUNE 1992 1007650

SHEET 10 OF 10

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

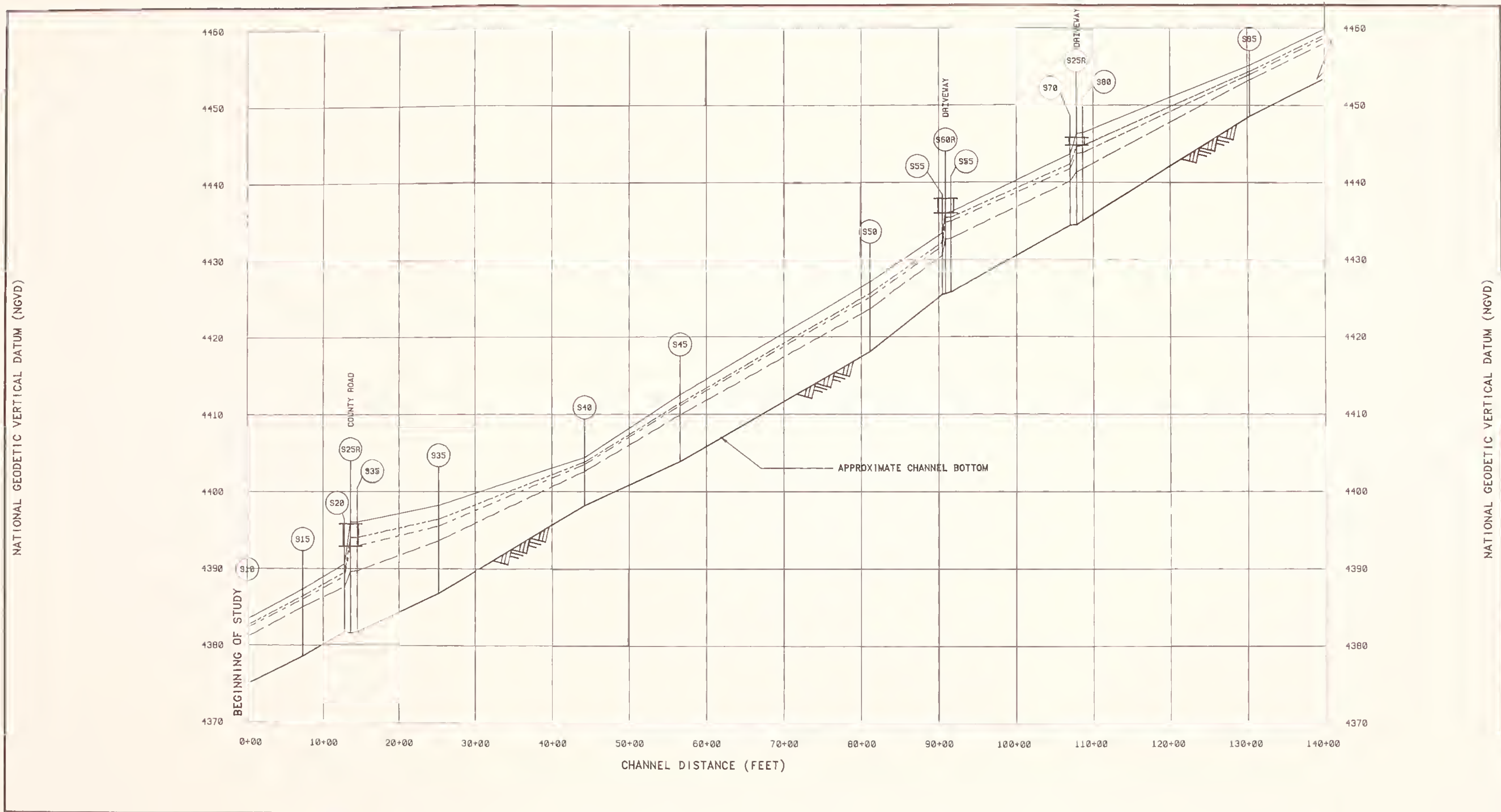
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

FLOOD HAZARD AREA

SHIELDS RIVER

APPENDIX B

FLOOD PROFILE SHEETS



SHIELDS RIVER

WATER SURFACE PROFILES

SHIELDS RIVER

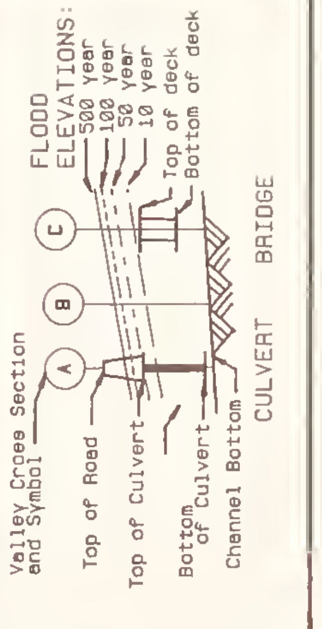
FLOOD PLAIN MANAGEMENT STUDY

PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



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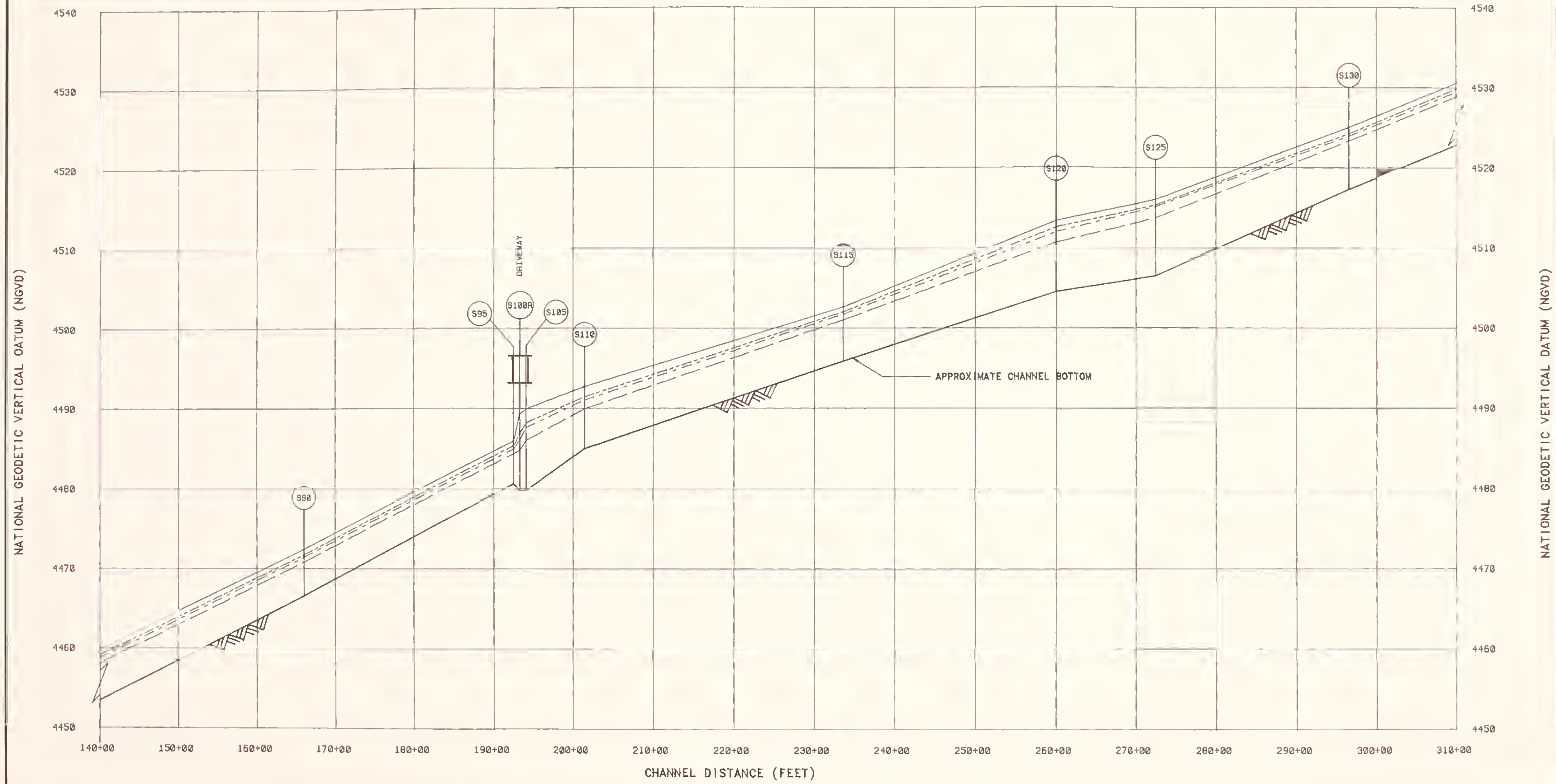


SHIELDS RIVER
WATER SURFACE PROFILES

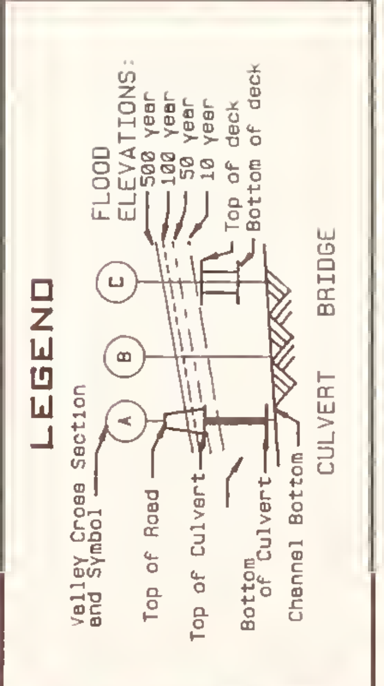
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY

PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



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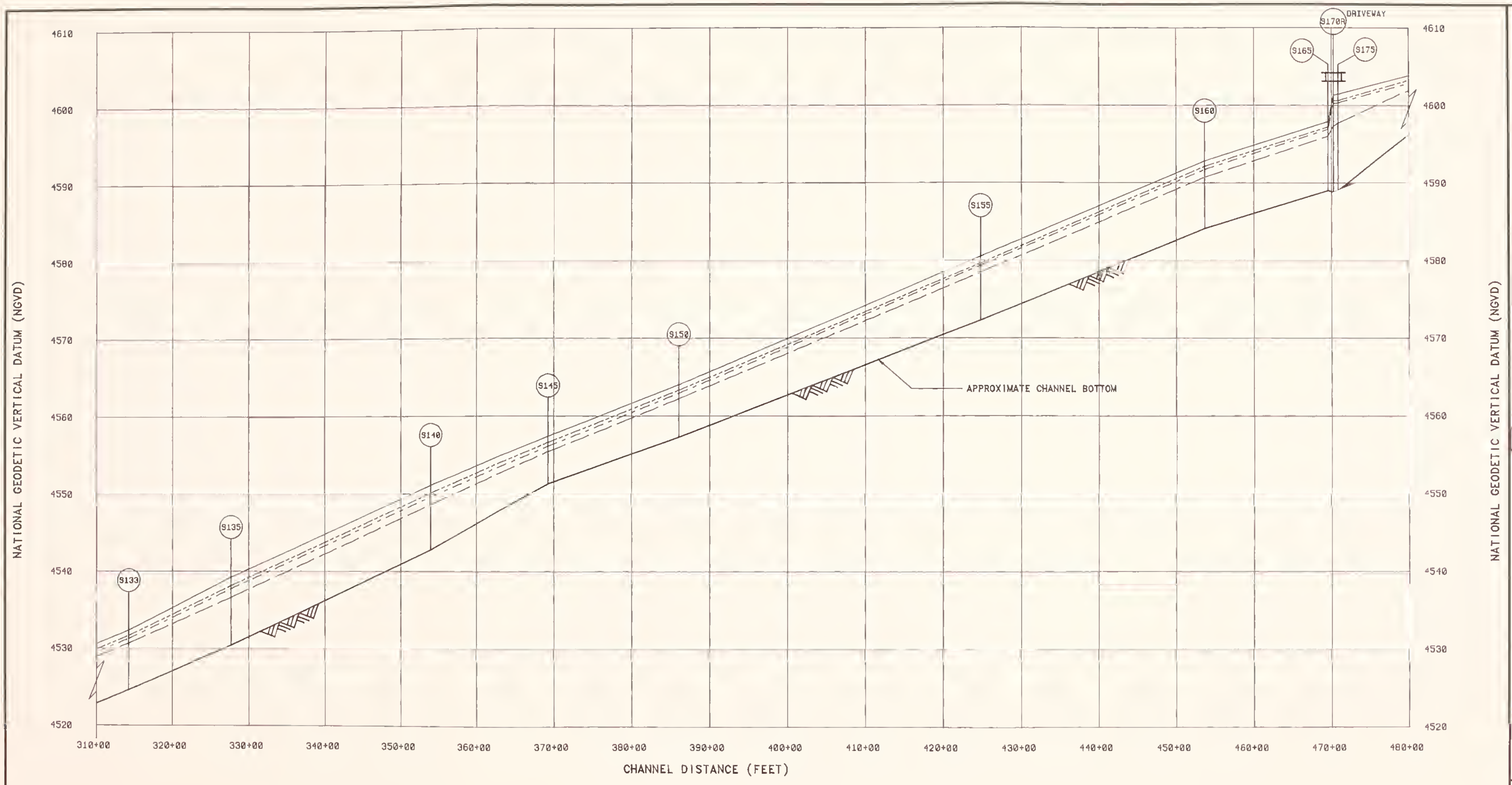
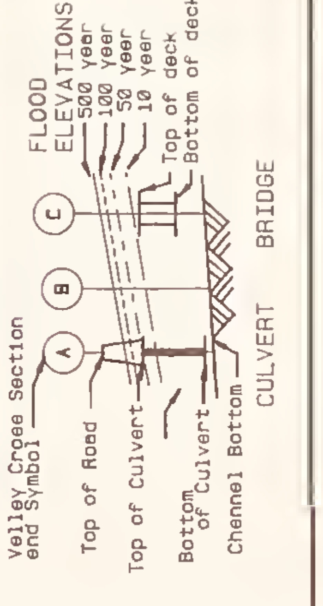


SHIELDS RIVER
WATER SURFACE PROFILES
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

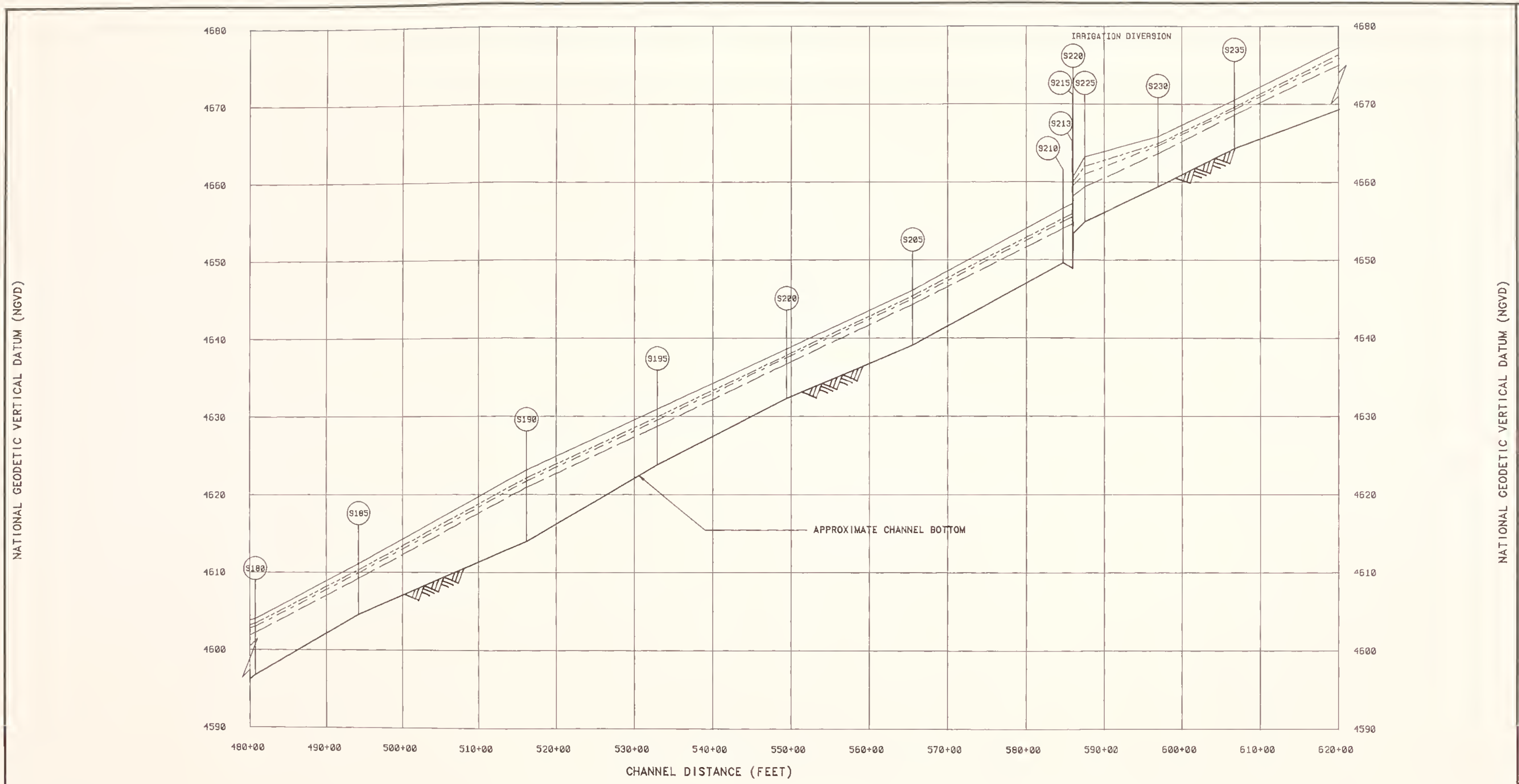
SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



PROFILE SHEET 3 OF 10



SHIELDS RIVER
WATER SURFACE PROFILES

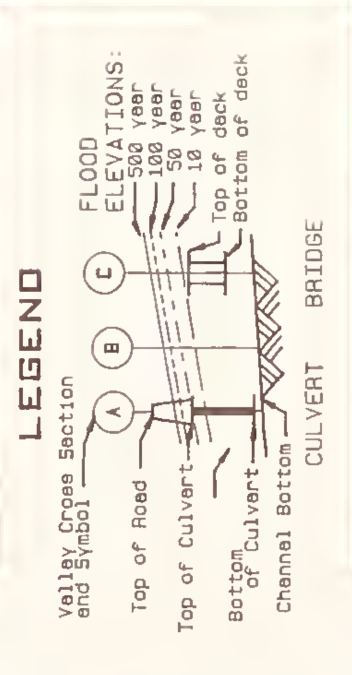
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY

PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



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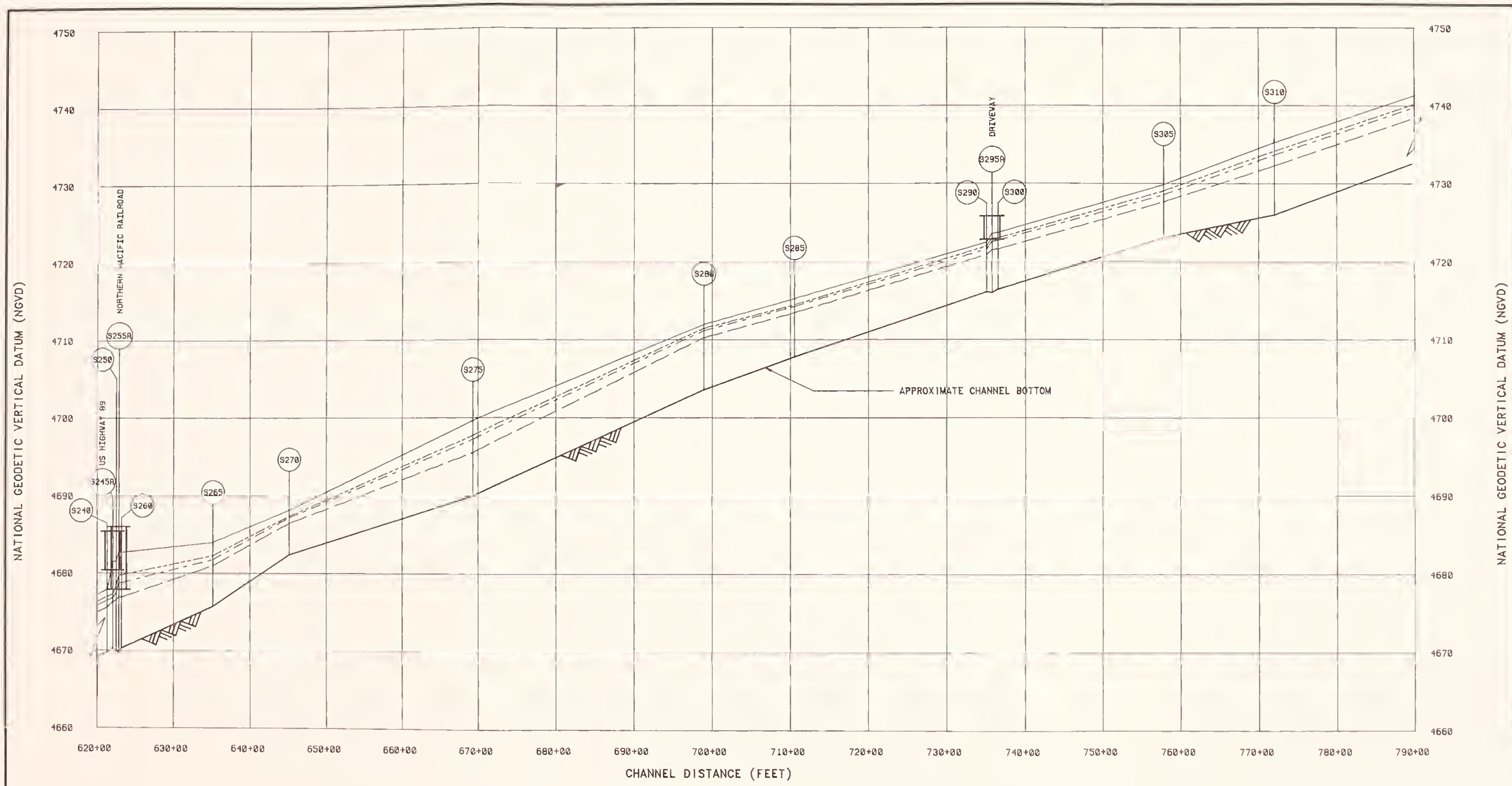


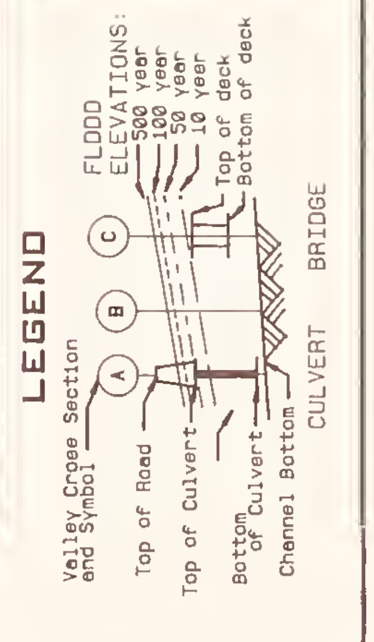
SHIELDS RIVER
WATER SURFACE PROFILES

SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

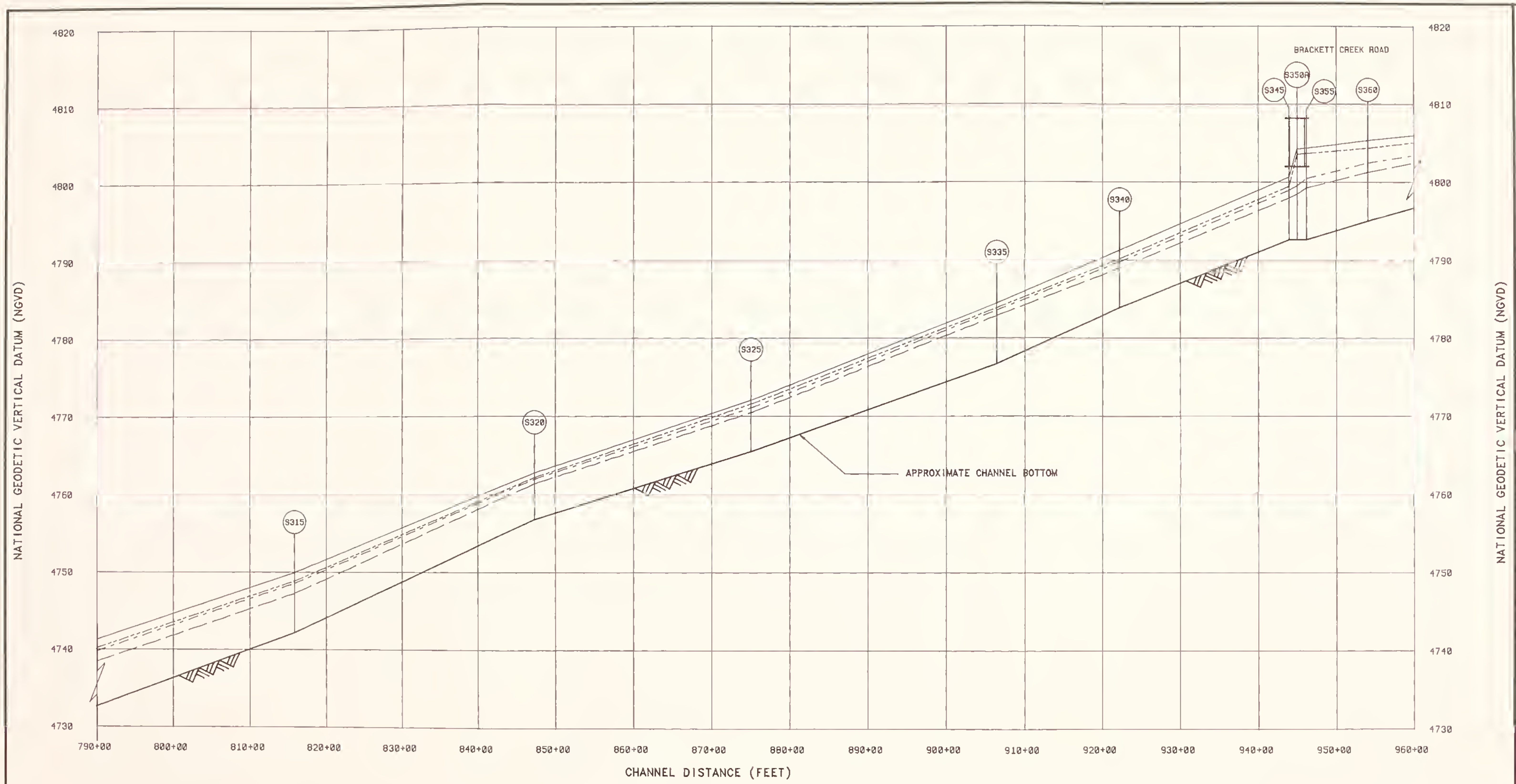
SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



PROFILE SHEET 5 OF 10



SHIELDS RIVER
WATER SURFACE PROFILES

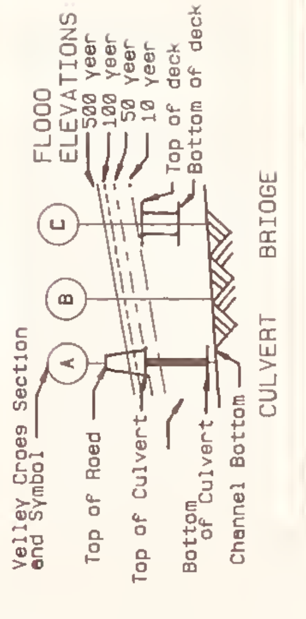
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY

PARK COUNTY, MONTANA

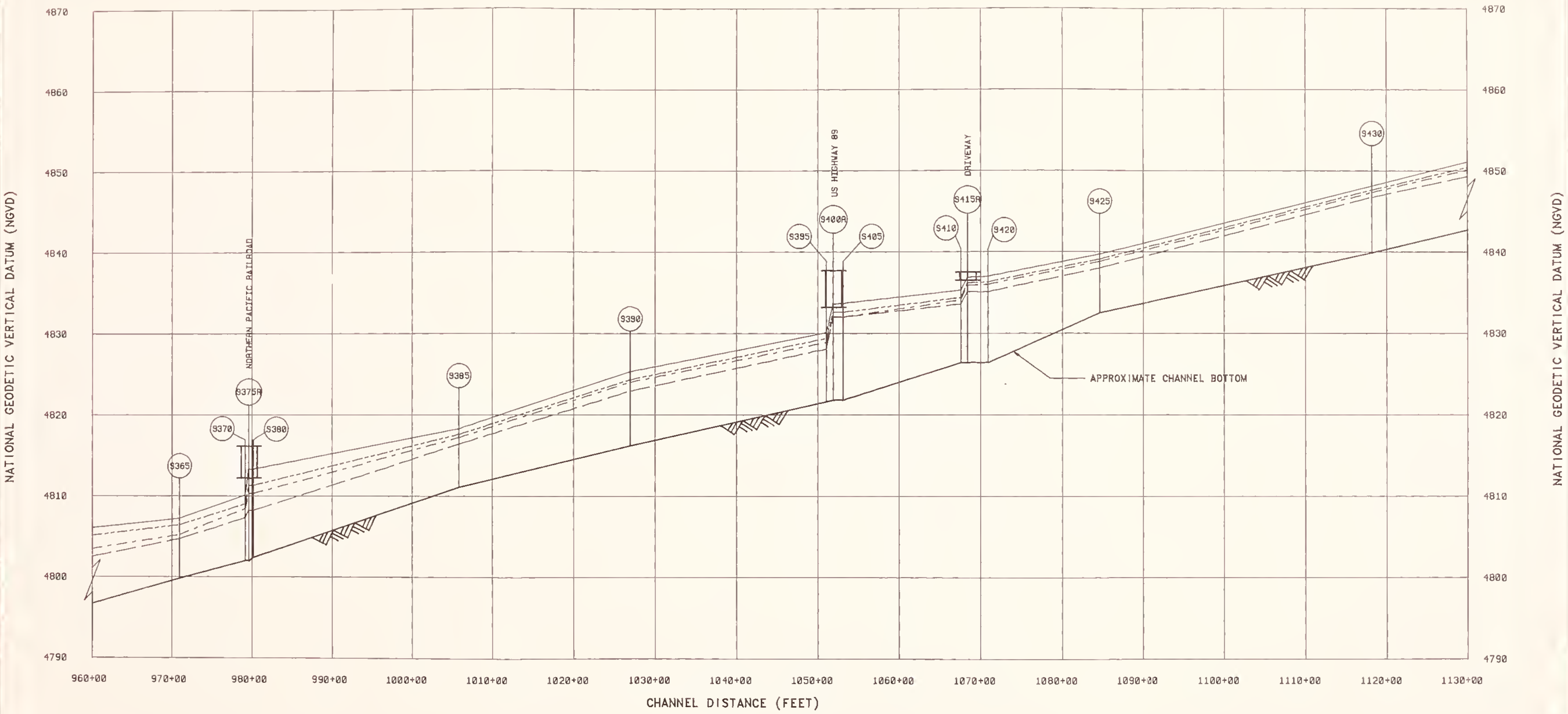
SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



PROFILE SHEET 6 OF 10

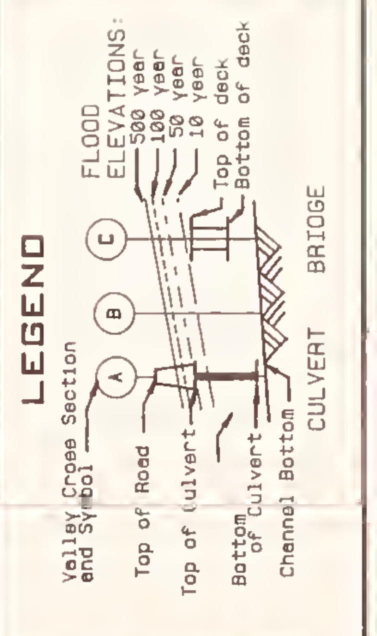


SHIELDS RIVER
WATER SURFACE PROFILES
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

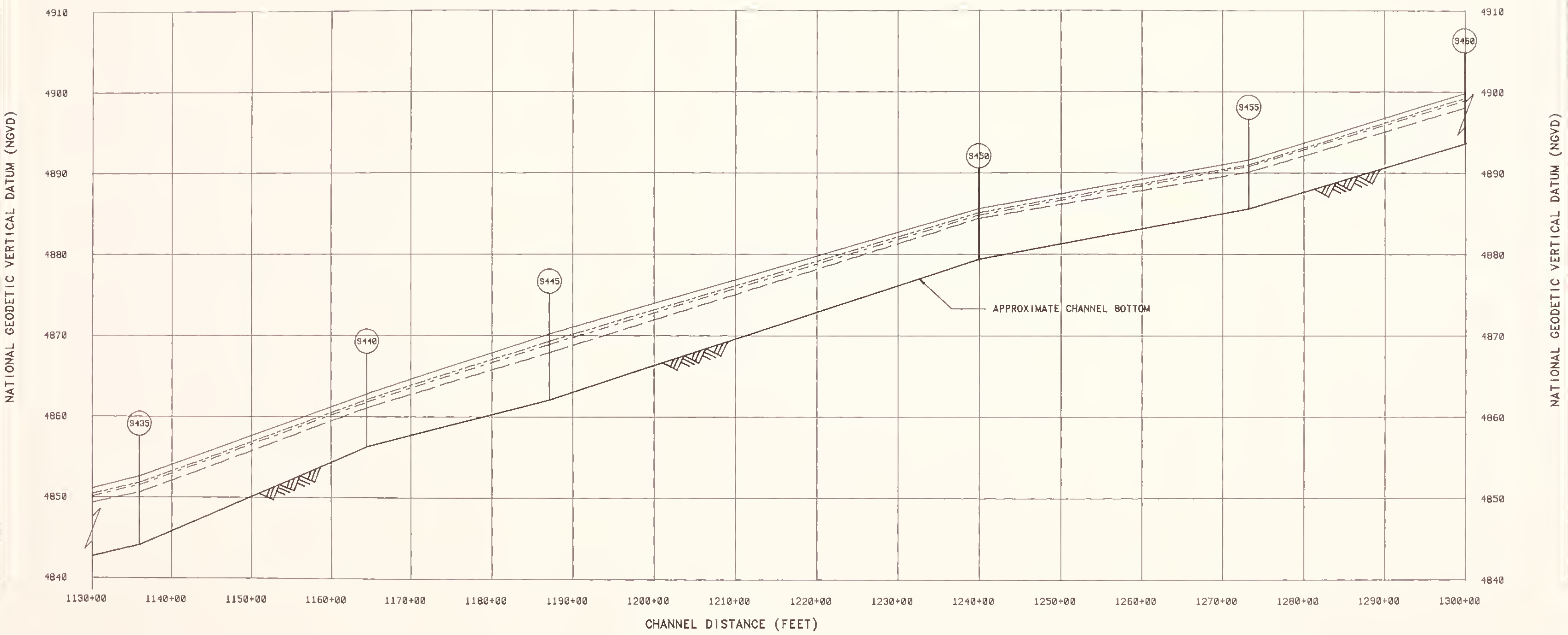
SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



PROFILE SHEET 7 OF 10



SHIELDS RIVER

WATER SURFACE PROFILES

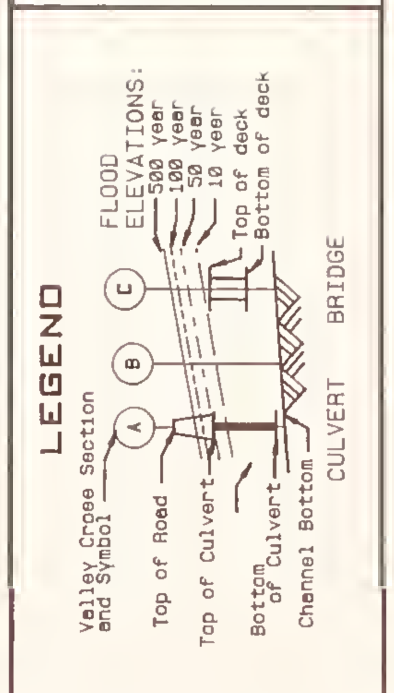
SHIELDS RIVER

FLOOD PLAIN MANAGEMENT STUDY

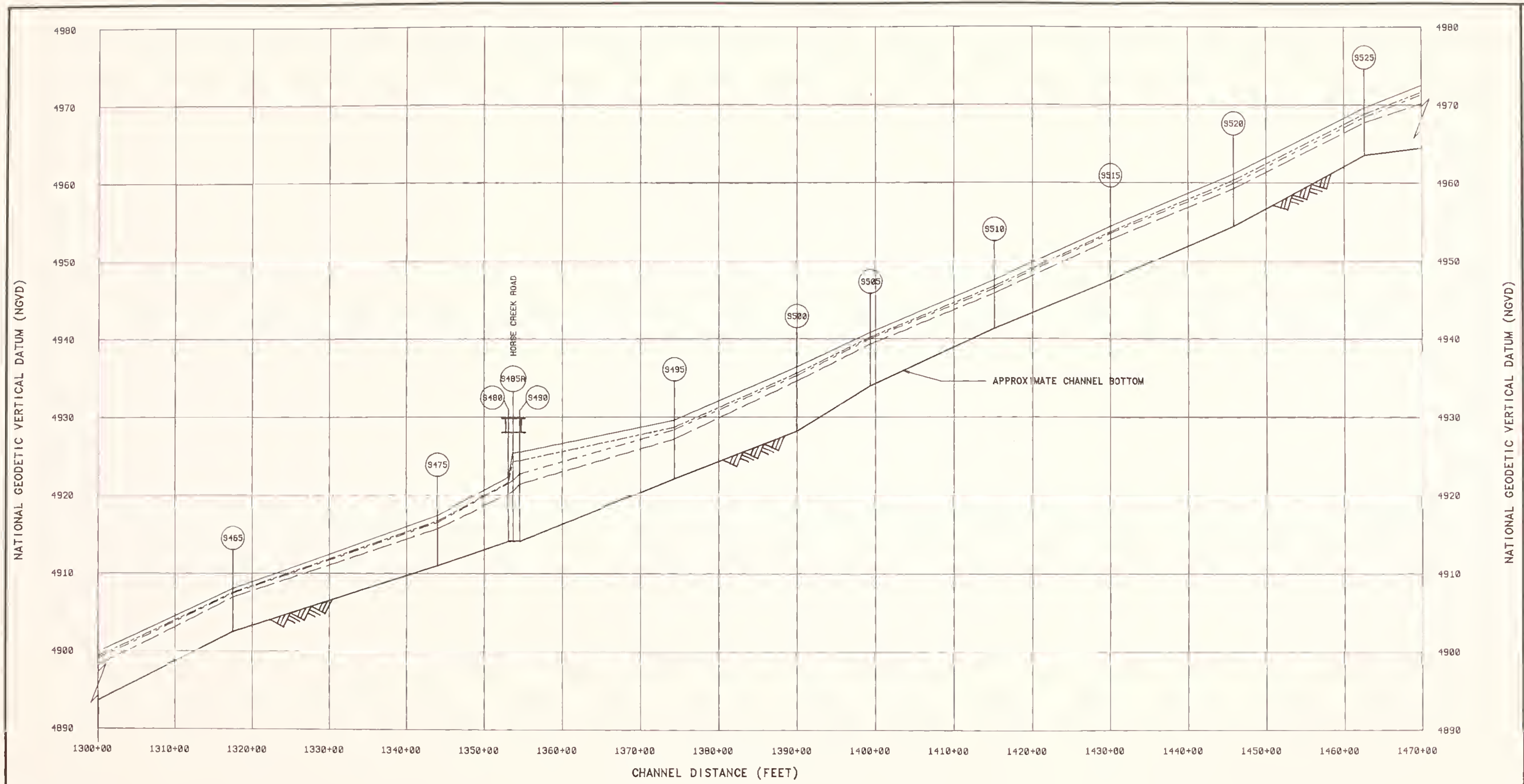
PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE



PROFILE SHEET 8 OF 10



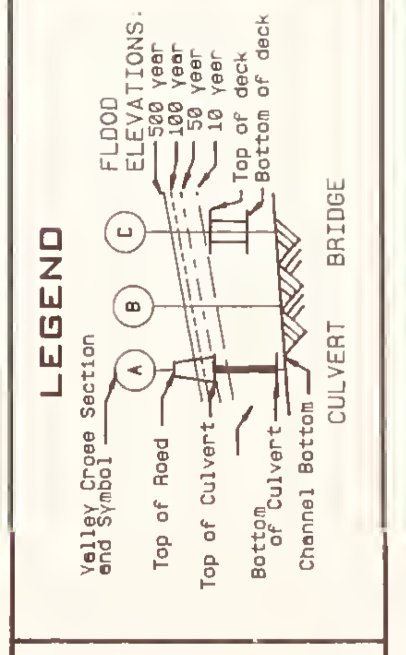
SHIELDS RIVER
WATER SURFACE PROFILES

SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

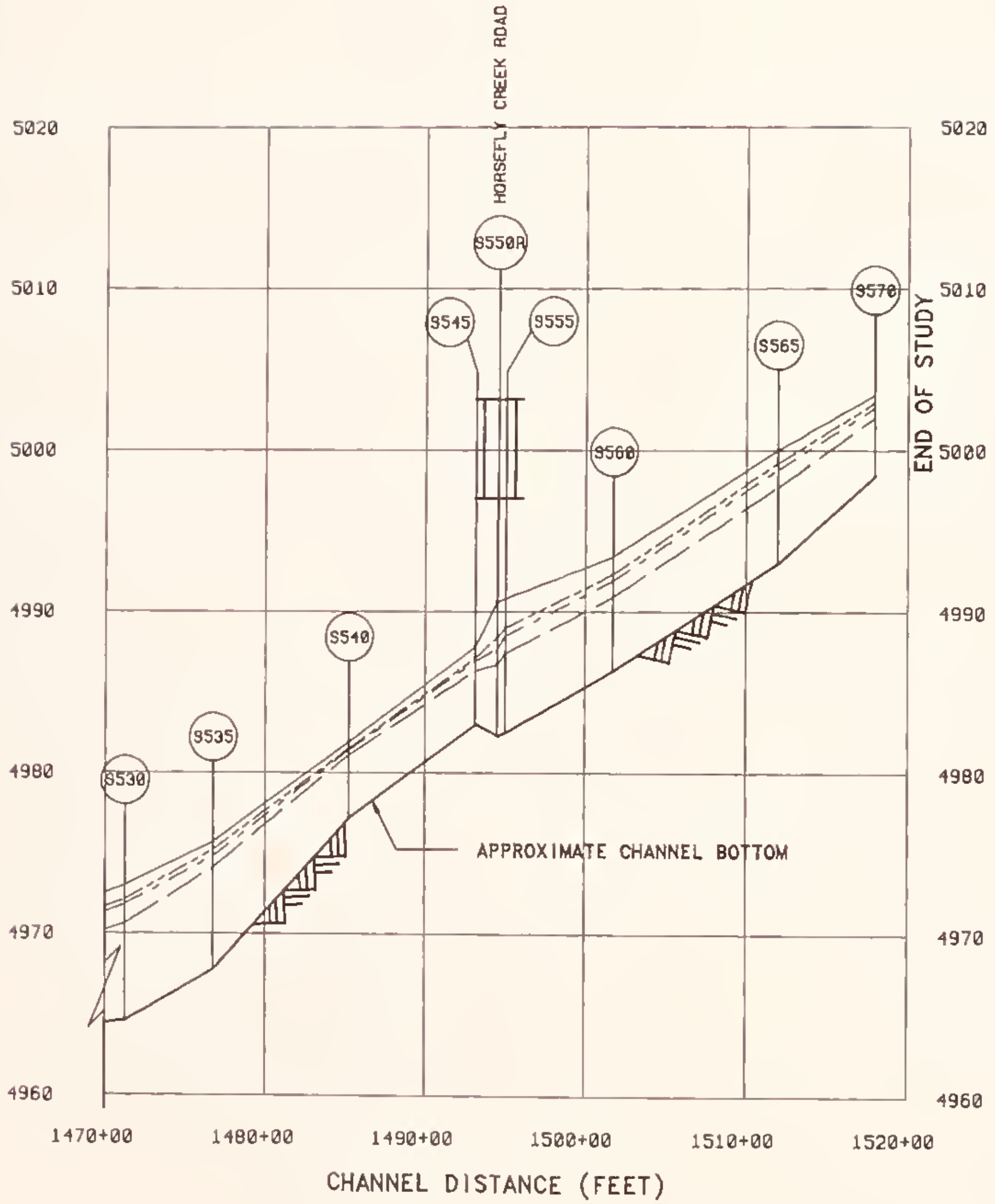
SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND

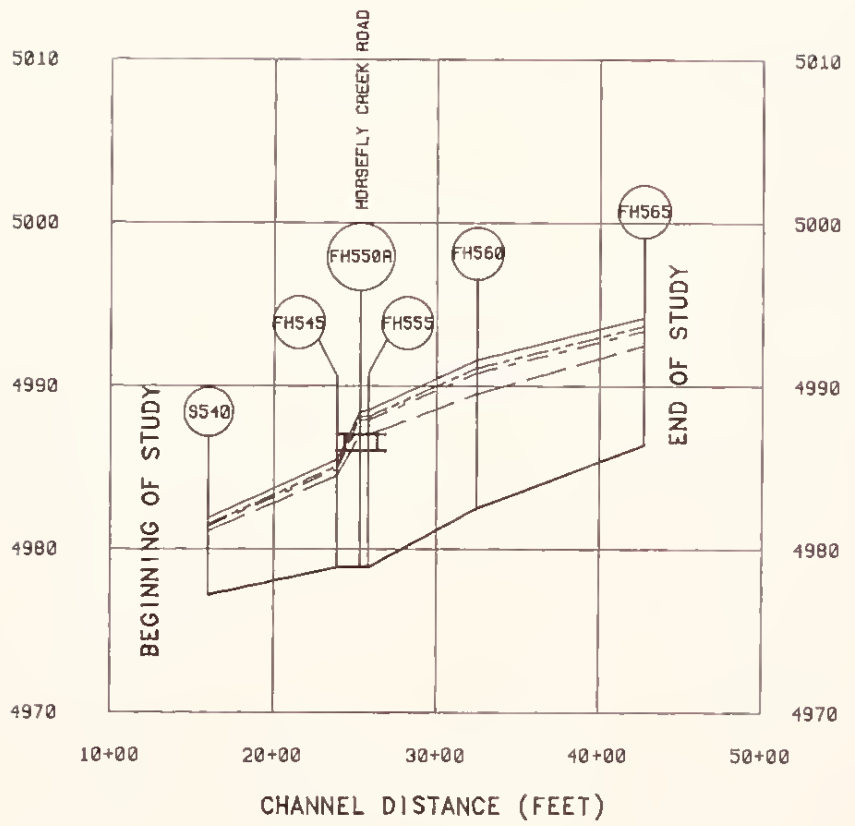


PROFILE SHEET 9 OF 10

SHIELDS RIVER



FLATHEAD CREEK

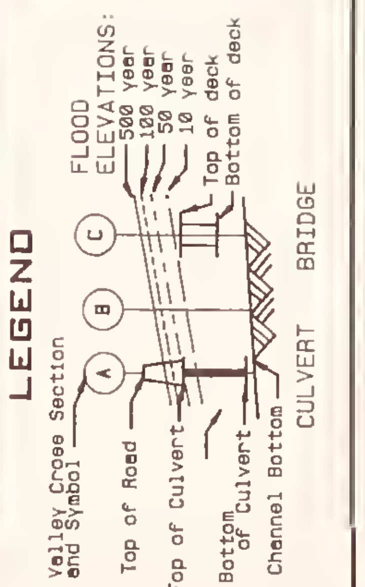


SHIELDS RIVER
WATER SURFACE PROFILES
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

SCALE
Horizontal: 1 inch=1000 feet
Vertical: 1 inch=10 feet

LEGEND

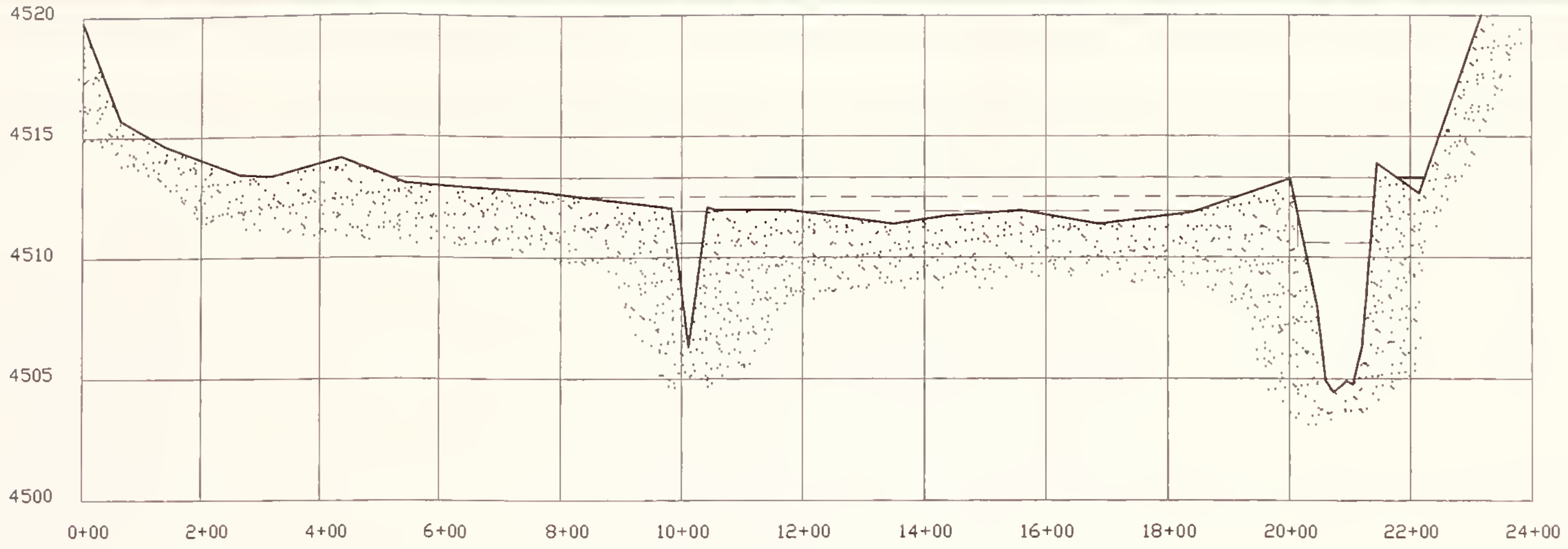


PROFILE SHEET 10 OF 10

APPENDIX C

SELECTED CROSS SECTIONS

NATIONAL GEODETIC VERTICAL DATUM (NGVD)



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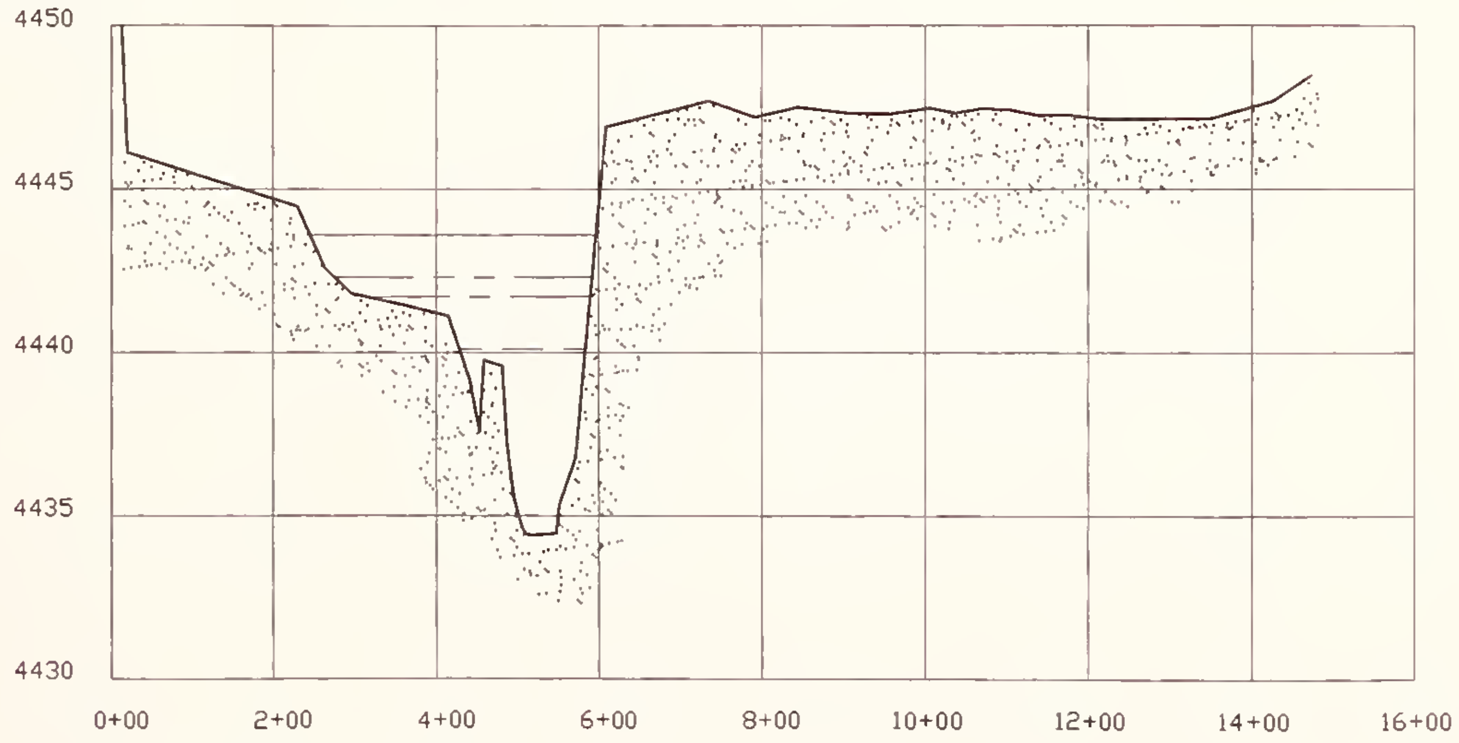


CROSS SECTION NAME : S70

NATIONAL GEODETIC VERTICAL DATUM (NGVD)

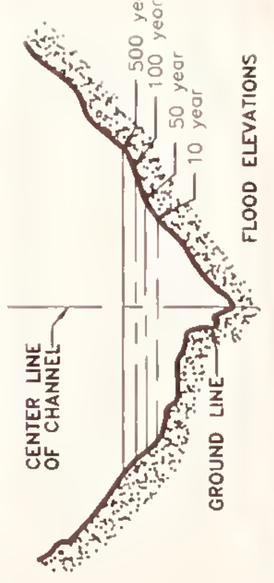
SHIELDS RIVER
TYPICAL CROSS SECTIONS

SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

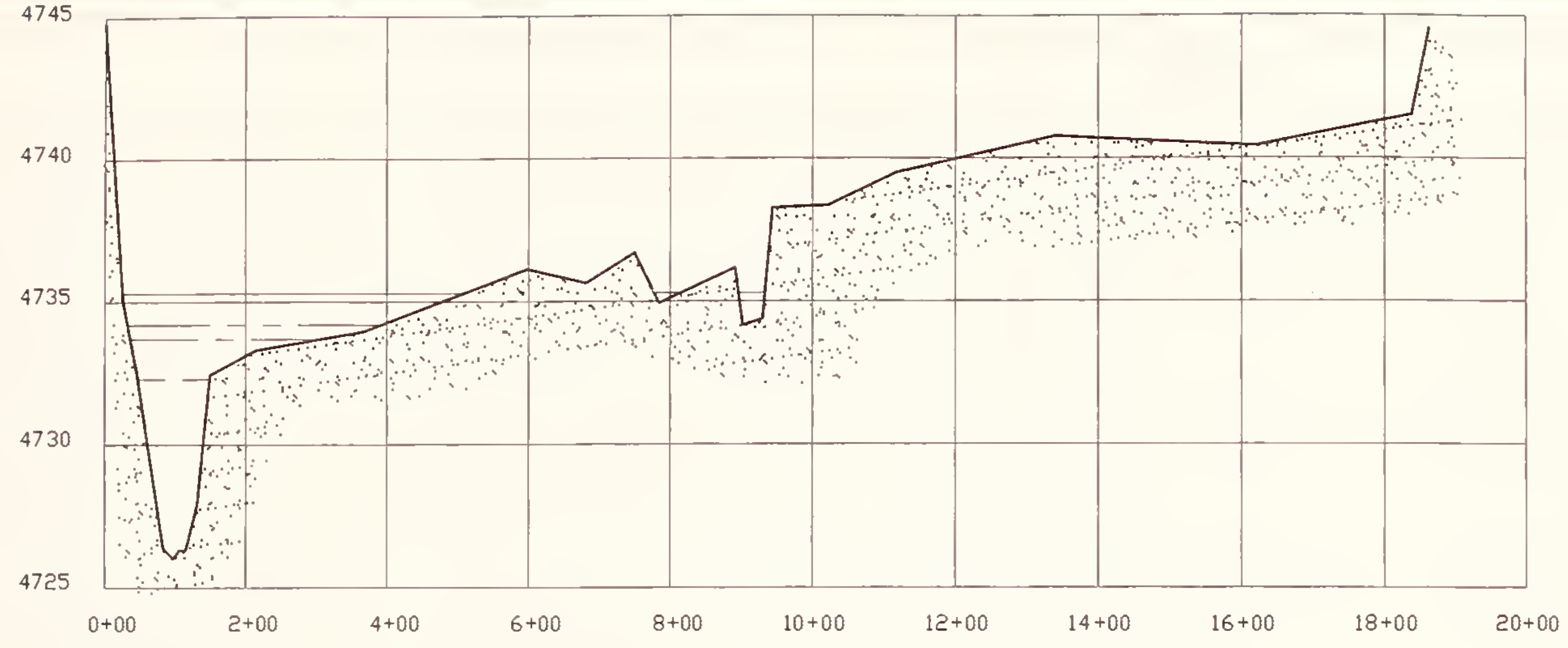
SCALE
Horizontal: 1 inch=500 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



SHEET 1 OF 3



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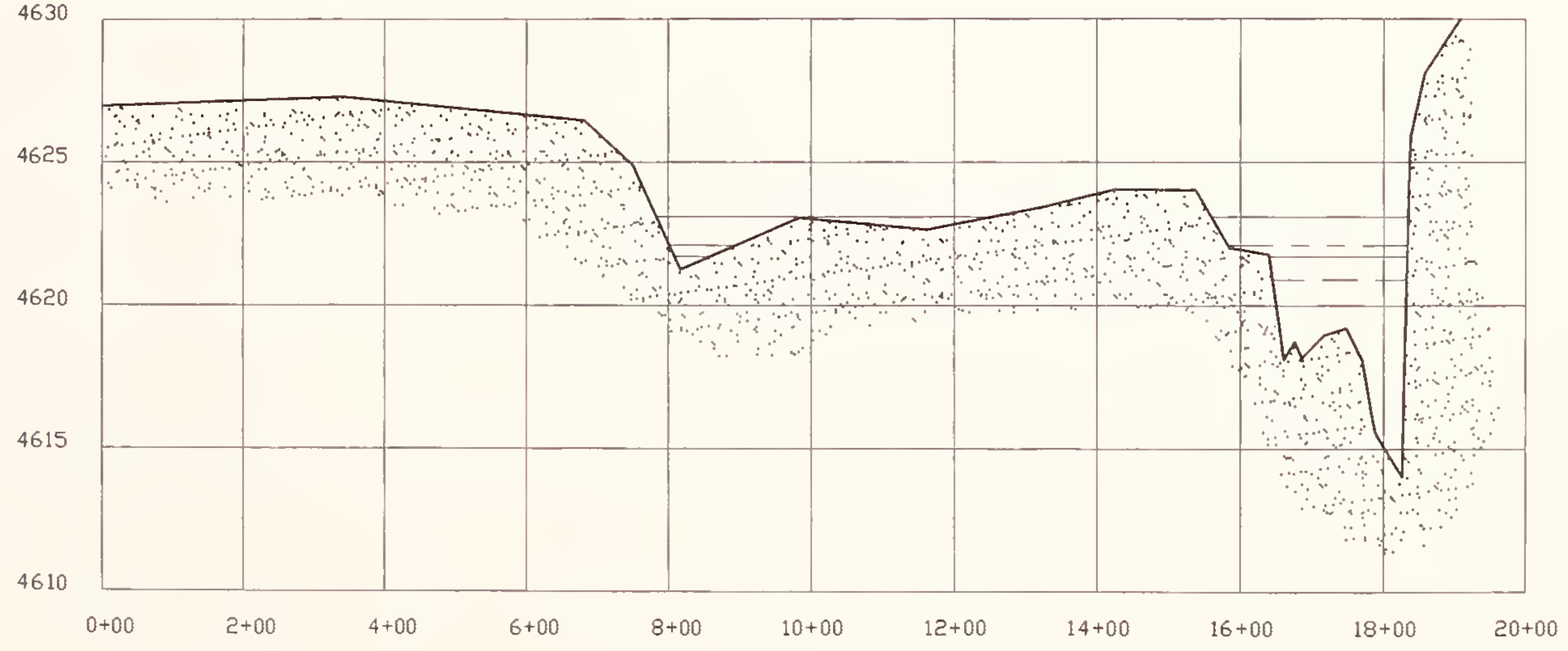


CROSS SECTION NAME : S190

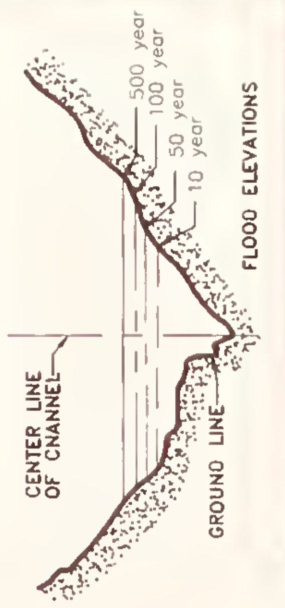
SHIELDS RIVER
TYPICAL CROSS SECTIONS

SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

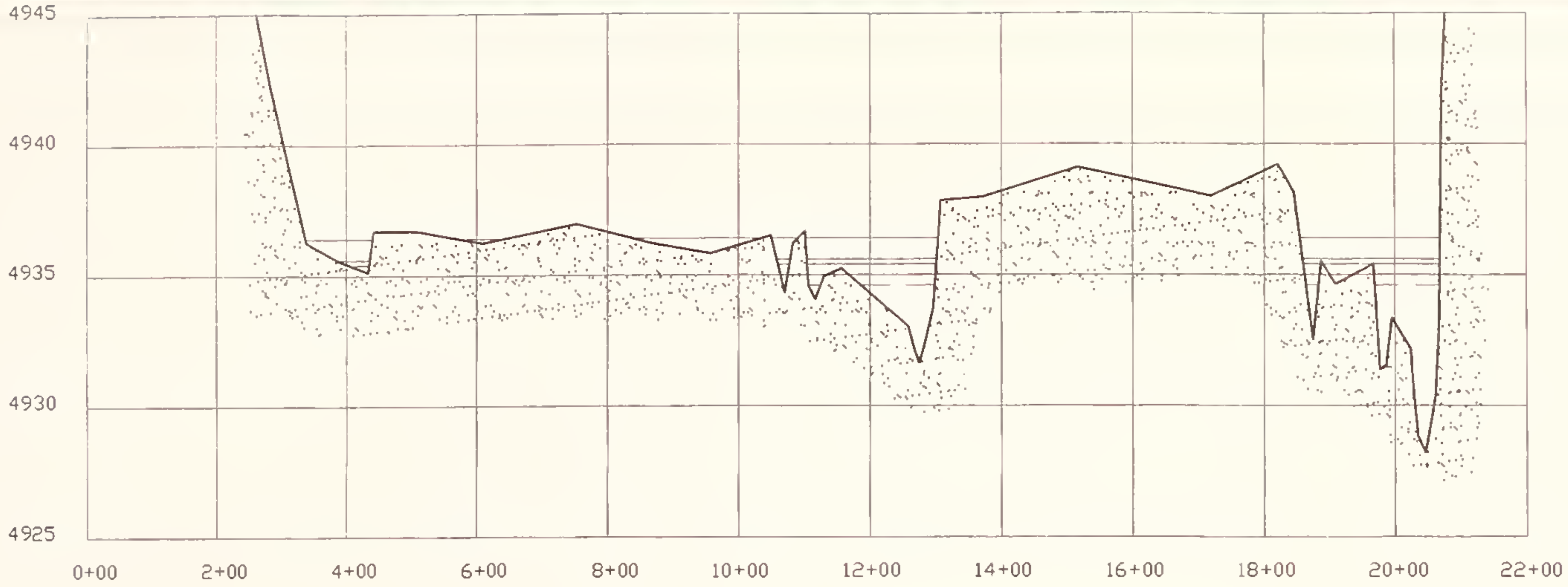
SCALE
Horizontal: 1 inch=500 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



SHEET 2 OF 3



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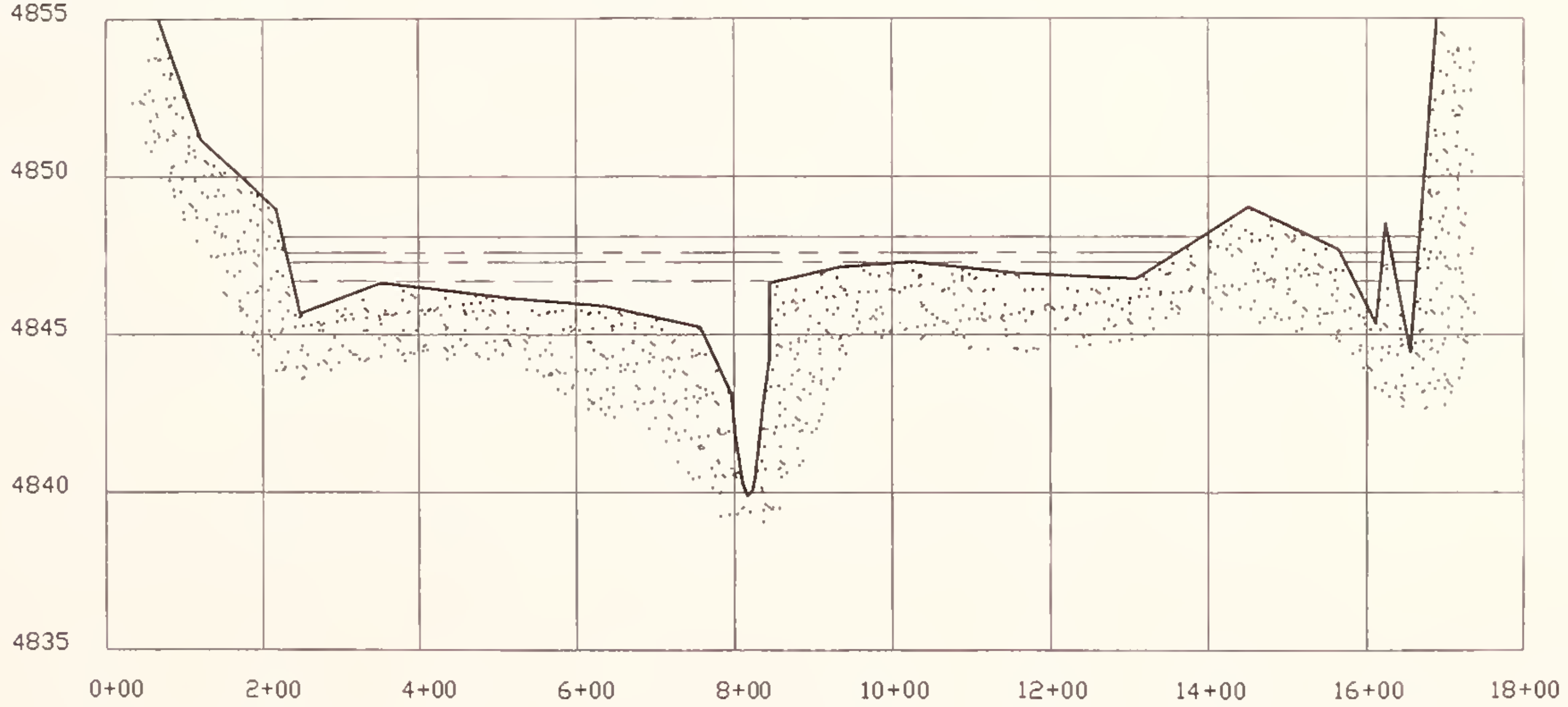


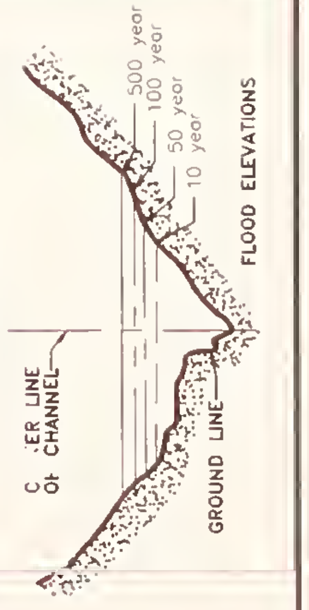
CROSS SECTION NAME : S430

SHIELDS RIVER
TYPICAL CROSS SECTIONS
SHIELDS RIVER
FLOOD PLAIN MANAGEMENT STUDY
PARK COUNTY, MONTANA

SCALE
Horizontal: 1 inch=500 feet
Vertical: 1 inch=10 feet

SOIL CONSERVATION SERVICE
U.S. DEPARTMENT OF AGRICULTURE

LEGEND



SHEET 3 OF 3

APPENDIX D

TABLE 1 Flood Discharges for Selected Frequencies by Study Reaches

TABLE 2 Flood Frequency--Elevation Data

TABLE 3 Floodway Data

TABLE 4 Acres Flooded

TABLE 1

FLOOD DISCHARGES FOR SELECTED FREQUENCIES BY STUDY REACHES

Study Reach Description	Drainage Area (Square Miles)	Peak Discharges (Cubic Feet per Second) 10-yr	50-yr	100-yr	500-yr
SHIELDS RIVER					
At Wilsall Section S545-S570	188	1431	2422	2950	4486
Below Flathead Creek Section S525-S540	417	2114	3578	4358	6629
Below Horse Creek Section S465-S520	456	2208	3737	4553	6926
Below Big Indian Creek Section S445-S460	478	2260	3826	4660	7087
Below Antelope Creek Section S395-S440	502	2315	3918	4773	7259
Below Looking Glass Creek Section S360-S390	518	2351	3979	4847	7372
Below Cottonwood Creek Section S320-S355	554	2452	4151	5056	7691
Below Bracket Creek Section S285-S315	622	2740	4639	5650	8594
Below Rock Creek Section S205-S280	675	2890	4980	6111	9448
Below Chicken Creek Section S185-S200	724	3091	5327	6536	10104
Below Tobin Creek Section S140-S180	745	3177	5475	6717	10385
Below Falls Creek Section S110-S135	817	3471	5981	7339	11346
Below Bullrun Creek Section S10-S105	856	3630	6255	7675	11865
FLATHEAD CREEK					
Entire Reach Section FH545-FH565	229	1576	2668	3250	4943

TABLE 2

FLOOD FREQUENCY-ELEVATION DATA

Cross Section	Channel Station	Streambed Elevation	10-year Flood	50-year Flood	100-year Flood	500-year Flood
SHIELDS RIVER						
S10	0+00	4375.0	4381.1	4382.3	4382.6	4383.4
S15	7+30	4378.6	4385.0	4386.0	4386.4	4387.3
S20	12+80	4381.8	4387.6	4389.0	4389.5	4390.6
S25R	13+60	4381.6	4389.6	4392.9	4394.0	4396.0
S30	14+50	4381.8	4389.7	4392.9	4394.0	4396.0
S35	25+20	4386.8	4393.6	4395.5	4396.4	4398.2
S40	44+20	4398.2	4402.6	4403.5	4403.8	4404.4
S45	56+60	4403.9	4409.9	4411.1	4411.4	4412.5
S50	81+10	4418.1	4423.6	4425.1	4425.6	4427.1
S55	90+45	4425.1	4430.1	4431.5	4432.0	4433.1
S60R	90+85	4425.2	4432.3	4434.5	4435.0	4435.6
S65	91+55	4425.4	4432.3	4434.5	4435.1	4435.7
S70	106+95	4434.0	4439.7	4441.4	4441.9	4443.2
S75R	107+80	4434.1	4440.9	4443.3	4444.3	4446.0
S80	108+60	4434.6	4441.3	4443.4	4444.3	4446.0
S85	130+30	4448.2	4452.9	4453.6	4454.0	4454.8
S90	166+00	4466.2	4470.4	4471.0	4471.3	4472.0
S95	192+40	4480.6	4484.2	4484.9	4485.3	4485.9
S100R	193+25	4479.8	4484.8	4486.1	4486.9	4489.3
S105	194+05	4479.8	4486.0	4487.6	4488.2	4489.9
S110	201+40	4485.0	4489.9	4491.0	4491.4	4492.7
S115	233+55	4495.9	4501.0	4501.7	4502.0	4502.6
S120	259+95	4504.5	4510.6	4511.9	4512.5	4513.3
S125	272+45	4506.5	4513.7	4515.1	4515.3	4516.0
S130	296+55	4517.3	4523.3	4523.9	4524.2	4525.0
S133	314+25	4524.6	4530.6	4531.2	4531.6	4532.3
S135	327+65	4530.4	4536.6	4537.7	4538.1	4539.2
S140	353+95	4542.8	4548.6	4549.6	4550.1	4551.1
S145	369+25	4551.3	4555.4	4556.1	4556.6	4557.4
S150	386+05	4557.3	4562.2	4562.9	4563.3	4564.0
S155	424+75	4572.3	4578.4	4579.3	4579.6	4580.5
S160	453+65	4584.1	4590.7	4591.7	4592.1	4592.8
S165	469+55	4589.0	4596.0	4596.9	4597.2	4597.9
S170R	470+25	4588.8	4597.3	4600.2	4600.6	4601.3
S175	470+85	4589.0	4597.7	4600.3	4600.6	4601.4
S180	480+70	4596.8	4602.2	4603.0	4603.4	4604.0
S185	494+20	4604.6	4609.2	4609.9	4610.3	4611.1
S190	516+20	4614.0	4620.9	4621.7	4622.1	4623.1
S195	532+90	4623.8	4628.7	4629.5	4629.9	4630.9
S200	549+40	4632.3	4636.7	4637.5	4637.8	4638.6
S205	565+50	4639.1	4644.3	4645.0	4645.4	4646.1
S210	584+70	4649.6	4654.0	4654.9	4655.3	4656.6
S213	585+90	4648.9	4654.6	4655.5	4655.9	4657.2

TABLE 2

FLOOD FREQUENCY-ELEVATION DATA

Cross Section	Channel Station	Streambed Elevation	10-year Flood	50-year Flood	100-year Flood	500-year Flood
SHIELDS RIVER						
S215	585+95	4652.1	4656.1	4657.5	4658.1	4660.2
S220	586+00	4653.4	4658.2	4659.6	4660.1	4660.7
S225	587+50	4654.9	4659.4	4661.0	4662.0	4663.2
S230	596+90	4659.4	4663.6	4664.6	4664.9	4665.8
S235	606+70	4664.3	4668.6	4669.3	4669.6	4670.5
S240	621+30	4669.8	4675.6	4676.5	4677.0	4677.9
S245R	622+05	4670.3	4676.3	4676.8	4677.3	4681.5
S250	622+50	4670.0	4676.5	4677.5	4678.3	4681.6
S255R	622+85	4669.8	4676.9	4678.8	4679.8	4682.7
S260	623+20	4670.3	4676.9	4678.8	4679.8	4682.7
S265	635+10	4675.7	4681.0	4681.8	4682.3	4684.0
S270	645+10	4682.4	4686.5	4687.2	4687.4	4688.2
S275	669+30	4690.0	4695.6	4697.3	4697.8	4699.7
S280	698+90	4703.6	4710.3	4711.2	4711.5	4712.0
S285	710+50	4707.8	4713.5	4714.3	4714.5	4715.3
S290	735+05	4716.1	4720.9	4721.6	4722.0	4722.5
S295R	735+75	4716.0	4721.5	4722.6	4723.0	4723.6
S300	736+50	4716.4	4721.6	4722.7	4723.0	4723.7
S305	757+80	4723.1	4727.7	4728.6	4729.1	4729.9
S310	772+00	4726.0	4732.3	4733.7	4734.2	4735.3
S315	815+80	4742.2	4747.3	4748.6	4748.9	4750.0
S320	847+30	4756.8	4761.4	4762.0	4762.2	4762.8
S325	875+00	4765.5	4770.5	4771.1	4771.6	4772.1
S335	906+40	4776.7	4782.9	4783.6	4783.9	4784.5
S340	922+20	4783.9	4789.0	4789.8	4790.2	4791.3
S345	943+90	4792.6	4798.0	4799.0	4799.5	4800.7
S350R	944+95	4792.6	4798.5	4799.6	4803.6	4804.3
S355	946+15	4792.6	4799.3	4800.5	4803.7	4804.4
S360	954+05	4795.0	4801.3	4802.5	4804.4	4805.4
S365	970+95	4799.8	4804.7	4805.2	4806.4	4807.2
S370	979+15	4802.0	4807.3	4808.4	4809.0	4810.1
S375R	979+60	4802.0	4808.2	4810.3	4811.3	4813.3
S380	980+15	4802.4	4808.2	4810.3	4811.3	4813.3
S385	1005+85	4811.1	4816.4	4817.2	4817.6	4818.3
S390	1026+95	4816.2	4822.9	4824.0	4824.3	4825.3
S395	1051+05	4821.6	4828.1	4828.9	4829.4	4830.1
S400R	1051+90	4821.8	4832.0	4832.0	4832.6	4833.6
S405	1053+10	4821.8	4832.0	4832.0	4832.6	4833.7
S410	1067+60	4826.4	4833.6	4834.1	4834.4	4835.3
S415R	1068+40	4826.4	4835.1	4835.9	4836.2	4836.9
S420	1070+90	4826.4	4835.1	4836.0	4836.3	4837.0
S425	1084+60	4832.5	4838.0	4838.8	4839.1	4839.7

TABLE 2

FLOOD FREQUENCY-ELEVATION DATA

Cross Section	Channel Station	Streambed Elevation	10-year Flood	50-year Flood	100-year Flood	500-year Flood
SHIELDS RIVER						
S430	1118+20	4839.9	4846.7	4847.3	4847.6	4848.1
S435	1135+90	4844.1	4850.6	4851.5	4851.8	4852.6
S440	1164+50	4856.3	4861.1	4861.8	4862.1	4862.8
S445	1187+10	4862.1	4867.9	4868.9	4869.3	4870.2
S450	1239+90	4879.4	4884.4	4884.8	4885.1	4885.6
S455	1273+20	4885.6	4890.1	4890.8	4891.0	4891.6
S460	1299+90	4893.6	4898.0	4898.9	4899.2	4899.8
S465	1317+50	4902.5	4906.9	4907.4	4907.5	4908.0
S475	1344+00	4911.0	4915.7	4916.5	4916.7	4917.4
S480	1353+10	4914.1	4920.1	4921.5	4921.6	4922.3
S485R	1353+70	4914.1	4920.5	4921.9	4924.3	4925.4
S490	1354+55	4914.1	4921.4	4922.7	4924.4	4925.5
S495	1374+35	4922.1	4927.2	4928.4	4928.7	4929.6
S500	1389+95	4928.2	4934.6	4935.3	4935.6	4936.4
S505	1399+35	4934.0	4939.3	4940.0	4940.2	4940.8
S510	1415+15	4941.3	4945.8	4946.4	4946.7	4947.5
S515	1430+05	4947.5	4952.7	4953.5	4953.7	4954.4
S520	1445+85	4954.4	4959.3	4959.9	4960.3	4961.1
S525	1462+65	4963.5	4967.7	4968.4	4968.8	4969.6
S530	1471+25	4964.6	4970.6	4971.8	4972.1	4973.0
S535	1476+75	4967.8	4974.1	4974.8	4975.2	4975.7
S540	1485+25	4977.2	4981.1	4981.4	4981.5	4981.9
S545	1493+15	4983.0	4986.3	4986.9	4987.1	4987.8
S550R	1494+55	4982.3	4986.7	4987.7	4988.4	4990.6
S555	1495+05	4982.5	4987.4	4988.5	4989.0	4990.8
S560	1501+75	4986.3	4990.9	4991.9	4992.3	4993.4
S565	1511+95	4993.0	4997.7	4998.8	4999.2	5000.0
S570	1517+95	4998.4	5002.0	5002.6	5002.9	5003.4
FLATHEAD CREEK						
FH545	23+90	4978.9	4984.5	4984.9	4985.1	4985.5
FH550R	25+30	4978.9	4987.0	4987.9	4988.1	4988.4
FH555	25+80	4978.9	4987.0	4987.9	4988.1	4988.5
FH560	32+50	4982.5	4989.5	4990.8	4991.1	4991.6
FH565	42+70	4986.4	4992.5	4993.4	4993.7	4994.2

TABLE 3
FLOODWAY DATA

Cross	100-Year Flood Plain		Floodway		
Section	Width[1]	Elevation	Width[1]	Elevation	Elev. Increase.
S10	1132	4382.6	578	4383.0	0.4
S15	745	4386.4	337	4386.7	0.3
S20	317	4389.5	90	4390.0	0.5
S30	297	4394.0	227	4394.0	0.0
S35	364	4396.4	246	4396.7	0.3
S40	832	4403.8	636	4403.9	0.1
S45	466	4411.4	151	4411.6	0.2
S50	217	4425.6	169	4425.7	0.1
S55	416	4432.0	212	4432.1	0.1
S65	576	4435.1	295	4435.2	0.1
S70	314	4441.9	157	4442.1	0.2
S80	410	4444.3	218	4444.4	0.1
S85	610	4454.0	308	4454.1	0.1
S90	948	4471.3	521	4471.8	0.5
S95	1144	4485.3	926	4485.8	0.5
S105	357	4488.2	259	4488.7	0.5
S110	379	4491.4	178	4491.7	0.3
S115	1697	4502.0	831	4502.4	0.4
S120	1207	4512.5	426	4513.0	0.5
S125	1562	4515.3	1320	4515.8	0.5
S130	973	4524.2	714	4524.5	0.3
S133	575	4531.6	339	4531.8	0.2
S135	494	4538.1	400	4538.3	0.2
S140	532	4550.1	218	4550.5	0.4
S145	752	4556.6	574	4557.1	0.5
S150	442	4563.3	277	4563.3	0.0
S155	763	4579.6	393	4579.7	0.1
S160	792	4592.1	252	4592.6	0.5
S165	909	4597.2	598	4597.4	0.2
S175	1101	4600.6	575	4600.8	0.2
S180	1421	4603.4	742	4603.7	0.3
S185	585	4610.3	337	4610.8	0.5
S190	330	4622.1	226	4621.9	-0.2
S195	435	4629.9	425	4630.0	0.1
S200	730	4637.8	469	4638.1	0.3
S205	623	4645.4	270	4645.6	0.2
S210	199	4655.3	139	4655.5	0.2
S213	139	4655.9	139	4656.1	0.2
S215	154	4658.1	114	4658.0	-0.1
S220	479	4660.1	139	4660.1	0.0
S225	669	4662.0	556	4662.5	0.5
S230	453	4664.9	351	4665.1	0.2
S235	576	4669.6	330	4669.9	0.3
S240	434	4677.0	180	4677.2	0.2
S250	373	4678.3	103	4678.1	-0.2

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[1] Width of flooded area only--excludes high spots or islands.

TABLE 3 (continued)

Cross	100-Year Flood Plain		Floodway		
Section	Width 1/	Elevation	Width 1/	Elevation	Elev. Increase
S260	690	4679.8	366	4679.5	-0.3
S265	770	4682.3	547	4682.6	0.3
S270	501	4687.4	358	4687.7	0.3
S275	124	4697.8	87	4698.0	0.2
S280	661	4711.5	254	4711.6	0.1
S285	690	4714.5	221	4715.0	0.5
S290	978	4722.0	407	4722.5	0.5
S300	873	4723.0	629	4723.5	0.5
S305	798	4729.1	224	4729.5	0.4
S310	361	4734.2	119	4734.5	0.3
S315	275	4748.9	213	4749.0	0.1
S320	1253	4762.2	379	4762.5	0.3
S325	1172	4771.6	255	4772.0	0.4
S335	705	4783.9	334	4784.4	0.5
S340	261	4790.2	133	4790.6	0.4
S345	333	4799.5	342	4799.6	0.1
S355	612	4803.7	254	4803.0	-0.7
S360	328	4804.4	191	4804.1	-0.3
S365	561	4806.2	560	4806.2	0.0
S370	293	4809.0	185	4809.0	0.0
S380	1219	4811.3	375	4810.6	-0.7
S385	983	4817.6	773	4817.9	0.3
S390	502	4824.3	214	4824.8	0.5
S395	1022	4829.4	447	4829.8	0.4
S405	1455	4832.6	976	4832.6	0.0
S410	983	4834.4	435	4834.7	0.3
S420	1172	4836.3	688	4836.4	0.1
S425	1337	4839.1	301	4839.4	0.3
S430	1168	4847.6	473	4848.0	0.4
S435	602	4851.8	560	4852.1	0.3
S440	551	4862.1	481	4862.2	0.1
S445	401	4869.3	110	4869.5	0.2
S450	972	4885.1	608	4885.6	0.5
S455	1103	4891.0	441	4891.3	0.3
S460	622	4899.2	612	4899.2	-0-
S465	1199	4907.5	463	4908.0	0.5
S475	613	4916.7	529	4917.0	0.3
S480	825	4921.6	638	4921.7	0.1
S490	772	4924.4	764	4924.5	0.1
S495	863	4928.7	533	4928.8	0.1
S500	522	4935.6	405	4935.7	0.1
S505	385	4940.2	359	4940.3	0.1
S510	593	4946.7	317	4947.0	0.3
S515	708	4953.7	122	4953.7	-0-
S520	492	4960.3	252	4960.7	0.4
S525	458	4968.8	226	4969.3	0.5
S530	458	4972.1	567	4972.5	0.4
S535	804	4975.2	735	4975.1	-0.1
S540	1363	4981.4	835	4981.3	-0.1
S545	207	4987.1	185	4987.2	0.1

TABLE 3 (continued)

Cross Section	100-Year Flood Plain Width 1/	Elevation	Floodway Width 1/	Elevation	Elev. Increase
S555	77	4989.0	60	4989.1	0.1
S560	364	4992.3	217	4992.3	-0-
S565	188	4999.2	166	4999.2	-0-
S570	264	5002.9	247	5002.8	-0.1
		Flathead Creek			
FH545	1382	4985.1	743	4985.5	0.4
FH555	1376	4988.1	1029	4988.3	0.2
FH560	461	4991.1	255	4991.5	0.4
FH565	924	4993.7	501	4994.1	0.4

TABLE 4

ACRES FLOODED

			100-Year Flooded Area Data			
	Total Acres Flooded		Acres Flooded			Buildings Flooded
Stream	500-Year	100-Year	Cropland	Rangeland & Channel	Urban	Residences and Farmsteads
Shields River and Flathead Creek (entire study area)	2,520	1,995	1,100	895	-0-	8

APPENDIX E

ELEVATION REFERENCE MARKS

SHIELDS RIVER
ELEVATION REFERENCE MARKS

R.M. No.	Survey No.	Elevation (ft)	Description
1.	BM #10	4423.29	SCS temporary bench mark. Top of 5/8" rebar located about 0.75 miles east of State Highway 89, on east side of Convick Grade road, 1.4 feet west of fence post. Top of rebar is about 0.1 foot above ground. NE 1/4 NW 1/4 Sec 26, T1S, R10E.
2.	BM #9	4395.28	SCS temporary bench mark. Top of 5/8" rebar located about 0.45 miles east of State Highway 89, on northwest cor of Convick Grade road bridge over the Shields River, on top of abutment, a chiselled X on top of abutment, 0.5 foot west of wood guard rail post with stake, 0.1 foot south of edge of north edge of abutment. NE 1/4 NW 1/4 Sec 26, T1S, R10E.
3.	BM #8	4408.95	SCS temporary bench mark. Top of 5/8" rebar located about 0.2 miles east of State Highway 89, on north side of Convick Grade road, 1.85 feet south of ninth fence post west of gate post in fence. Top of rebar is about 0.1 foot above ground. NE 1/4 NE 1/4 Sec 27, T1S, R10E.
4.	BM #7	4423.07	SCS temporary bench mark. Top of 5/8" rebar located about 0.6 miles north of State Highway 89 bridge over Yellowsone River, 2.8 feet west of west rail of Northern Pacific Railroad, about half way between the county road and siphon under railroad. Top of rebar is about 0.1 foot above ground. SW 1/4 SE 1/4 Sec 22, T1S, R10E.
5.	BM #6	4429.09	SCS temporary bench mark. Top of 5/8" rebar located about 0.9 miles north of State Highway 89 bridge over Yellowsone River, about 130 feet south of 2 mile marker on Northern Pacific Railroad, 4.5 feet east of east rail. Top of rebar is about 0.15 foot above ground. SW 1/4 SE 1/4 Sec 22, T1S, R10E.
6.	BM #5	4429.47	SCS temporary bench mark. Top of 5/8" rebar located about 1.3 miles north of State Highway 89 bridge over Yellowsone River, 6.2 feet north of wood rail crossing over Northern Pacific Railroad, 2.3 feet west of west rail. Top of rebar is about 0.1 foot above ground. NE 1/4 SW 1/4 Sec 22, T1S, R10E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
7.	Brass Cap	4426.38	USGS bench mark. Present condition is good. Located about 1.55 miles north of State Highway 89 bridge over Yellowsone River,just south of stream gaging site on shields river, a brass cap in a concrete post. SE 1/4 NW 1/4 Sec 22, T1S, R10E.
8.	BM #4	4446.72	SCS temporary bench mark. Top of 5/8" rebar located about 1.8 miles north of State Highway 89 bridge over Yellowsone River, west of 3 foot concrete pipe under State Highway 89, about 45 feet south of 4 foot CMP under Northern Pacific Railroad, 2.5 feet west of west rail. Top of rebar is about 0.15 foot above ground. NE 1/4 NW 1/4 Sec 22, T1S, R10E.
9.	AV9	4480.85	USGS bench mark stamped "AV9". Present condition good. Located across from Grannis School, 275 feet northwest of milepost 4, 144 feet southwest of schoolhouse, 100 feet south of T-junction of State Highway 89 and county road, 42 feet east of east rail. A brass cap in a concrete post. NW 1/4 NE 1/4 Sec 16, T1S, R10E.
10.	BM #11	4494.32	SCS temporary bench mark. Top of 5/8" rebar located about 3.3 miles north of State Highway 89 bridge over Yellowsone River, just south of siphon under State Highway 89, 3 feet west of west rail of Northern Pacific Railroad, 0.4 of a mile south of highway mile marker 5. Top of rebar is about 0.1 foot above ground. SW 1/4 SE 1/4 Sec 9, T1S, R10E.
11.	BM #13	4512.27	SCS temporary bench mark. Located about 4.1 miles north of State Highway 89 bridge over Yellowsone River, on the southwest corner of bridge on the Northern Pacific Railroad, 2.3 feet west of west rail, 0.4 foot north of south edge of wood abutment, 5.85 feet east of west end of abutment. Top of nail with an aluminum plate. NE 1/4 NW 1/4 Sec 9, T1S, R10E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
12.	BM #14	4533.79	SCS temporary bench mark. Top of 5/8" rebar located about 4.4 miles north of State Highway 89 bridge over Yellowsone River, 23.4 feet south of private drive crossing Northern Pacific Railroad, 1.6 feet west of west rail. Top of rebar is about 0.1 foot above ground. SE 1/4 SW 1/4 Sec 4, T1S, R10E.
13.	D 128	4565.28	C&GS bench mark stamped "D 128." Located 2.1 miles north along Northern Pacific Railroad from Grannis School, 0.1 mile north of mile post 6, at siphon 6+567, in surface of foundation, 10 west of center line of track. A brass cap. NW 1/4 NW 1/4 Sec 4, T1S, R10E.
14.	BM #16	4577.42	SCS temporary bench mark. Top of 5/8" rebar located about 5.4 miles north of State Highway 89 bridge over Yellowsone River, about 45 feet north of field entrance over Northern Pacific Railroad, 6.9 feet east of steel sign post along railroad, 3.1 feet west of west rail. Top of rebar is about 0.1 foot above ground. SE 1/4 SW 1/4 Sec 32, T1N, R10E.
15.	BM #17	4582.74	SCS temporary bench mark. Top of 5/8" rebar located about 5.75 miles north of State Highway 89 bridge over Yellowsone River, 1.7 feet west of steel sign (white) along Northern Pacific Railroad, 7.7 feet east of east rail. Top of rebar is about 0.1 foot above ground. SE 1/4 NW 1/4 Sec 32, T1N, R10E.
16.	BM #18	4577.96	SCS temporary bench mark. Top of 5/8" rebar located about 6.0 miles north of State Highway 89 bridge over Yellowsone River, 12 feet north of Hay Hook Ranch field road over Northern Pacific Railroad, 2.7 feet east of east rail. Top of rebar is about 0.1 foot above ground. SE 1/4 NW 1/4 Sec 32, T1N, R10E.
17.	BM #19	4579.34	SCS temporary bench mark. Located about 6.3 miles north of State Highway 89 bridge over Yellowsone River, on the southeast corner of bridge on the Northern Pacific Railroad over Willow Creek, 3.55 feet east of east rail, 3.95 feet west of end of abutment. Top of nail with an aluminum plate. NW 1/4 NW 1/4 Sec 32, T1N, R10E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
17.	BM #19	4579.34	SCS temporary bench mark. Located about 6.3 miles north of State Highway 89 bridge over Yellowsone River, on the southeast corner of bridge on the Northern Pacific Railroad over Willow Creek, 3.55 feet east of east rail, 3.95 feet west of end of abutment. Top of nail with an aluminum plate. NW 1/4 NW 1/4 Sec 32, T1N, R10E.
18.	BM #20	4589.33	SCS temporary bench mark. Top of 5/8" rebar located about 6.4 miles north of State Highway 89 bridge over Yellowsone River, about 50 feet north of field road over Northern Pacific Railroad, 5.4 feet east of railroad sign post, 2.75 feet west of west rail. Top of rebar is about 0.1 foot above ground. SW 1/4 SE 1/4 Sec 30, T1N, R10E.
19.	E 128	4618.26	C&GS bench mark stamped "E 128." Located 4.1 miles north along Northern Pacific Railroad from Grannis School, 45 feet west of State Highway 89, just north of county road, at siphon 8+781, in the top of the concrete foundation. A brass cap..SE 1/4 NW 1/4 Sec 30, T1N, R10E.
20.	BM #21	4628.99	SCS temporary bench mark. Top of 5/8" rebar located about 7.6 miles north of State Highway 89 bridge over Yellowsone River, at turn on south side of grain elevator, along Northern Pacific Railroad, 2.65 feet east railroad sign post, 7.5 west of west rail. Top of rebar is about 0.1 foot above ground. SW 1/4 NW 1/4 Sec 30, T1N, R10E.
21.	BM #22	4630.67	SCS temporary bench mark. Top of 5/8" rebar located about 7.9 miles north of State Highway 89 bridge over Yellowsone River, on east side of State Highway 89 at field entrance gate, 0.55 foot northwest of north gate post. Top of rebar is about 0.1 foot above ground. NW 1/4 NW 1/4 Sec 30, T1N, R10E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
22.	BM #23	4648.91	SCS temporary bench mark. Located about 8.2 miles north of State Highway 89 bridge over Yellowsone River, on top of northeast corner of siphon wall, west of Northern Pacific Railroad, 0.3 foot from north edge of wall, 0.45 foot from east edge of wall. Top of concrete with a chiselled X. SW 1/4 SE 1/4 Sec 24, T1N, R9E.
23.	BM #24	4657.33	SCS temporary bench mark. Located about 8.5 miles north of State Highway 89 bridge over Yellowsone River, on top of northwest corner of siphon wingwall, west of Northern Pacific Railroad, 0.55 foot from northwest corner , 0.5 foot from south edge of wall, .5 foot from north edge of wall. Top of concrete with a chiselled X. NW 1/4 SW 1/4 Sec 24, T1N, R9E.
24.	BM #26	4652.47	SCS temporary bench mark. Located about 9.1 miles north of State Highway 89 bridge over Yellowsone River, on northeast corner of concrete base of telephone junction box, 3.8 feet from south edge, 3.75 feet from west edge, 0.2 foot from west edge, 0.22 foot from east edge. Top of concrete with a chiselled X. SW 1/4 NW 1/4 Sec 24, T1N, R9E.
25.	BM #27	4661.18	SCS temporary bench mark. Top of 5/8" rebar located about 9.4 miles north of State Highway 89 bridge over Yellowsone River, on east side of State Highway 89, 6.8 feet northwest of power pole, 0.8 foot west of steel fence post. Top of rebar is about 0.1 foot above ground. SE 1/4 SE 1/4 Sec 14, T1N, R10E.
26.	BM #30	4685.58	SCS temporary bench mark. Located about 10.0 miles north of State Highway 89 bridge over Yellowsone River, on northeast abutment of State Highway 89 bridge over Shields River, 3.15 feet east of guardrail, 1.35 feet from north edge, 0.2 foot from south edge. Top of concrete with a chiselled X. NE 1/4 SE 1/4 Sec 14, T1N, R9E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
27.	BM #34	4731.29	SCS temporary bench mark. Located about 11.0 miles north of State Highway 89 bridge over Yellowsone River, on northwest abutment of State Highway 89 bridge over Rock Creek, 2.7 feet west of bridge gaurdrail, 1.1 foot from south edge, 0.85 foot from north edge, 0.6 foot from west edge. Top of concrete with a chiselled X. NW 1/4 SW 1/4 Sec 11, T1N, R9E.
28.	BM #37	4764.42	SCS temporary bench mark. Located about 11.9 miles north of State Highway 89 bridge over Yellowsone River, on the southeast corner of bridge on the Northern Pacific Railroad over Spring Creek, 5.75 feet from east rail, 1.2 foot west of end of abutment, 0.6 foot from south edge, 0.15 foot from north edge. Top of nail in abutment..SE 1/4 SE 1/4 Sec 3, T1N, R9E.
29.	BM #39	4792.80	SCS temporary bench mark. Top of 5/8" rebar located about 12.7 miles north of State Highway 89 bridge over Yellowsone River, on west side of State Highway 89, 5 feet east of wood fence post in right of way fence. Top of rebar is about 0.15 foot above ground. SE 1/4 NW 1/4 Sec 3, T1N, R9E.
30.	BM #40	4814.95	SCS temporary bench mark. Top of 5/8" rebar located about 13.0 miles north of State Highway 89 bridge over Yellowsone River, on west side of State Highway 89, at gate for field entrance, 0.5 foot east of first wood fence post north of gate. Top of rebar is about 0.1 foot above ground. NW 1/4 NW 1/4 Sec 3, T1N, R9E.
31.	BM #43	4801.37	SCS temporary bench mark. Top of 5/8" rebar located at Clyde Park, about 800 feet south of the Bracket Creek Road, in center line of Northern Pacific Railroad, 0.85 foot west of east rail, 0.40 foot east of west rail of mainline, about 420 feet south of fuel tanks. Top of rebar is about 0.1 foot above ground. SE 1/4 SW 1/4 Sec 33, T2N, R9E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
32.	JF 19	4812.37	USGS bench mark stamped "JF 19". Present condition. Located 230 feet south and 128 feet west of southwest corner of Northern Pacific Railroad station, 24 feet south and 89 feet west of railroad crossing on the main tracks, in the northwest concrete wingwall of culvert under tracks. A brass cap. SE 1/4 NW 1/4 Sec 33, T2N, R9E.
33.	BM #47	4815.87	SCS temporary bench mark. Located on south abutment of Northern Pacific Railroad over Shields River just north of Clyde Park, in center line of main tracks. Top of railroad spike. NE 1/4 SW 1/4 Sec 28, T2N, R9E.
34.	BM #50	4860.66	SCS temporary bench mark. Located on north abutment of Northern Pacific Railroad over Looking Glass Creek just north of Clyde Park, on northeast corner, 5.8 feet east of east rail, 1.2 foot west of east end of abutment. Top of nail on surface of abutment. NW 1/4 SW 1/4, Sec 21, T2N, R9E.
35.	BM #52	4879.44	SCS temporary bench mark. Top of 5/8" rebar located 5.4 miles south of Horsefly Creek near Wilsall, on east side of Northern Pacific Railroad, 7.4 feet east of east rail, 2.0 feet west of railroad mile post 17. Top of rebar is about 0.1 foot above ground. SW 1/4 SW 1/4 Sec 16, T2N, R9E.
36.	BM #54	4900.75	SCS temporary bench mark. Top of 5/8" rebar located 4.6 miles south of Horsefly Creek near Wilsall, on east side of Northern Pacific Railroad, 10.9 feet east of east rail, west of east-west fence line T. Top of rebar is about 0.1 foot above ground. NE 1/4 NE 1/4 Sec 17, T2N, R9E.
37.	BM #55	4910.89	SCS temporary bench mark. Top of 5/8" rebar located 4.6 miles south of Horsefly Creek near Wilsall, in center line of Northern Pacific Railroad main line, 2.35 feet east of west rail, 2.45 west of east rail, just north of reflector post on State Highway 89. Top of rebar is about 0.1 foot above ground. SE 1/4 SE 1/4 Sec 8, T2N, R9E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
38.	BM #56	4915.58	SCS temporary bench mark. Located 3.85 miles south of Horsefly Creek near Wilsall, on the northeast corner of abutment on Northern Pacific Railroad bridge over Antelope Creek, there is a railroad sign with the number 18 on it, 8.55 feet east of east rail, 0.9 foot from east end of abutment. Top of nail on surface of abutment. NW 1/4 SE 1/4, Sec 8, T2N, R9E.
39.	BM #57	4934.99	SCS temporary bench mark. Top of 5/8" rebar located 3.45 miles south of Horsefly Creek near Wilsall, 17.6 feet north of center line of driveway, 9.4 feet west of west rail of Northern Pacific Railroad, 1.5 foot north of railroad sign post. Top of rebar is about 0.2 foot above ground. NE 1/4 NW 1/4 Sec 8, T2N, R9E.
40.	BM #58	4946.41	SCS temporary bench mark. Top of 5/8" rebar located 2.9 miles south of Horsefly Creek near Wilsall, in center line of Northern Pacific Railroad, 2.5 feet east of west rail, 2.3 feet west of east rail, 0.05 mile north of railroad mile marker 20. Top of rebar is about 0.1 foot above ground. NE 1/4 SW 1/4 Sec 5, T2N, R9E.
41.	BM #59	4963.66	SCS temporary bench mark. Top of 5/8" rebar located 2.45 miles south of Horsefly Creek near Wilsall, on south bank of siphon, 40 feet east of center line Northern Pacific Railroad, across highway from state bench mark, 14.7 feet south of southeast cor siphon wall, 7.35 feet west of fence. Top of rebar is about 0.1 foot above ground. SW 1/4 SW 1/4 Sec 5, T2N, R9E.
42.	L 128	4959.53	C&GS bench mark stamped "E 128." Present condition good. Located at Shields, 16.8 feet east of center line of Northern Pacific Railroad, 40 feet north of center line of Indian Creek Road. road, A brass cap. NW 1/4 NW 1/4 Sec 5, T2N, R9E.

SHIELDS RIVER
ELEVATION REFERENCE MARKS
(continued)

R.M. No.	Survey No.	Elevation (ft)	Description
43.	BM #62	4970.32	SCS temporary bench mark. Top of 5/8" rebar located 1.75 miles south of Horsefly Creek near Wilsall, then 0.35 mile east of State Highway 89 on subdivision road at gate in fence, 19 feet east of south gate post, 1.5 feet east of second post from south gate post. Top of rebar is about 0.2 foot above ground. NE 1/4 SW 1/4 Sec 33, T3N, R9E.
44.	BM #65	4992.49	SCS temporary bench mark. Top of 5/8" rebar located 1.75 miles south of Horsefly Creek near Wilsall, then 0.35 mile east of State Highway 89 on subdivision road, 0.8 mile north along subdivision road at gate in fence, 8.6 feet west of west gate post, 1.15 foot east of first fence post from gate post, 0.91 foot south of fence. Top of rebar is about 0.1 foot above ground. NW 1/4 NW 1/4 Sec 32, T3N, R9E.
45.	BM #66	5008.41	SCS temporary bench mark. Top of 5/8" rebar located 1.75 miles south of Horsefly Creek near Wilsall, then 0.35 mile east of State Highway 89 on subdivision road, 1.1 mile north along subdivision road at gate in fence, at fence corner, 1.2 foot southwest of corner, 7.2 feet southeast of first post west of corner, 1.2 foot south of fence. Top of rebar is about 0.1 foot above ground. NE 1/4 SE 1/4 Sec 30, T3N, R9E.
46.	BM #69	4999.99	SCS temporary bench mark. Located on Horsefly Creek road bridge over Shields River southeast of Wilsall. On northwest corner of concrete abutment. A chiselled X on top surface of abutment. SE 1/4 SE 1/4 Sec 19, T3N, R9E.

APPENDIX F

INVESTIGATION AND ANALYSIS

Appendix F

INVESTIGATION AND ANALYSIS

Standard hydrologic and hydraulic study methods were used to determine the flood hazard data for the stream reaches studied for this report. Detailed methods were used on all study reaches. The 10, 50, 100 and 500-year recurrence interval floods were selected and analyzed because of their special significance for flood plain management.

Hydrologic Analysis

Hydrologic analysis was performed to determine the peak discharge-frequency relationships for floods in the Shields River reaches studied in this report.

The peak discharges from three USGS streamgages on the Shields River, as listed in table F-1, were analyzed. This analysis was made following the methods described in Guidelines for Determining Flood Flow Frequency, Bulletin 17B (Ref 8). The Corps of Engineers' computer program, HECWRC, was used for the analysis.

Table F-1. USGS Peak Discharge Records

Station Number	Station Name	Drainage Area (sq.miles)	Period of Record
6-193000	Shields River near Wilsall	87.8	1936-1957
6-193500	Shields River at Clyde Park	543	1921-1967
6-195600	Shields River near Livingston	852	1979-1990

The larger floods of record (i.e., 1943, 1948, and 1979) were treated as historical events. The record for the streamgage near Livingston was extended by estimating the 1943 and 1948 flood peaks. These estimates were made as a function of drainage area and the recorded values at the Clyde Park gage as described in Methods for Estimating Magnitude and Frequency of Floods in Montana (Ref 9). A 61-year historical period was thereby formed for the gage near Livingston. The record for the Clyde Park gage was extended in a similar manner by estimating the 1979 flood peak.

A regional analysis was made using 21 streams in the area. Most of these streams like the Shields River, have their headwaters in the Bridger Mountains or Crazy Mountains. The resulting equations related the peak discharge by frequency to the basin drainage area, mean elevation, percent over 6,000 feet, and annual precipitation. The regional equations compared very well with the lower gage near Livingston and the upper gage near Wilsall. The predicted peak at Clyde Park was 25 percent higher than the gage analysis. The regional analysis was used as an independent estimate with an accuracy equivalent to an estimate based on a 10-year record and a weighted average was calculated as described in Bulletin 17B. These weighted average values were used as the final values at the streamgage locations.

Because the peak discharge varies significantly from one end of the study to the other, the stream was broken down into a number of shorter reaches. The peak discharge-frequency values for each reach was interpolated from the streamgage values based on the drainage area at the reach. These values are shown in table 1 in Appendix D.

Hydraulic Analaysis

The hydraulic characteristics of the river were analyzed to determine the elevations of floods for the selected recurrence intervals at each cross section (see table 2, Appendix D).

Water surface elevations for floods with selected recurrence intervals were determined by using the Soil Conservation Service's computer program WSP-2. This program performs subcritical flow backwater computations by a modified step method from cross section data. The program computes head losses at restrictive sections, including roadways, with either a bridge opening or culverts by using the U.S. Bureau of Public Roads' methods (Ref 10, 11).

Cross section data were obtained from field surveys conducted in March and April of 1990, and completed during September and October of 1990. The data was tied to a network of control points and elevation reference marks established during the survey. Reference marks are shown on the maps and descriptions of them are listed in Appendix E. All surveys were tied to the National Geodetic Vertical Datum of 1929 (NGVD).

Starting elevations for the Shields River were determined using normal depth for each discharge at the downstream section, S10, at the Yellowstone River. The 100-year flood on the Shields River is not likely to occur at the same time as the 100-year flood on the Yellowstone, therefore, backwater was not considered. At the confluence of the rivers the water surface elevations for both flood plains need to be examined to determine the maximum flood elevation.

The starting elevations for Flathead Creek were taken from the flood profiles of the Shields River, and these flows were considered to be coincident. Flood elevations for the common flood plain just upstream of the confluence for these streams was computed based on the total flow expected.

Channel roughness factor (Mannings "n") used for channel area in this study varied from .033 to .055. An analysis of the streamgage stations was used to help in assigning "n" values. The value of "n" for the channel was found to vary with the hydraulic radius. For flood plain areas, values of .045 in open areas up to .085 in brushy areas were used.

Head losses through restrictive sections and roadways were calculated without considering either the effect of debris or the possibility that the embankment might wash out.

Enlargements of USGS orthophoto quadrangle maps were used for the base map for the flood plain maps in the report. Aerial photography taken by the Montana Highway Department at a larger scale were very helpful for locating the flood plain between cross sections.

Floodways were intially determined by using the FLDWY computer program (Ref 12). This program uses the conveyance values in the segments of each cross section. The conveyance of the left and right flood plains are both reduced by one-half of the increase in the channel conveyance for an elevation increase of 0.5 feet.

The final determination of the floodway was made with WSP2. The left and right stationing from FLDWY was entered as encroachment limits on WSP2 and a true change in elevation determined. This may not be the same as for FLDWY because of changing friction slope and backwater effects. The left and right encroachments were then adjusted to insure that the increased stage was less than the 0.5 feet allowed by state law. Table 3 in Appendix D shows the width and elevation increase of the floodway.

Flood profiles were drawn for the channels studied in this report. The flood profiles show the locations of cross sections used in the hydraulic analysis and the computed water surface elevations (see Appendix B). The flood hazard photo maps (Appendix A), show cross section, locations, 100 and 500-year flood plain, and computed floodways. Typical cross sections are shown in Appendix C.

APPENDIX G

GLOSSARY OF TERMS

GLOSSARY OF TERMS

cfs	Cubic feet per second (a unit of measure of liquids flowing past a given point).
cross section	Shape and dimensions of a channel and valley perpendicular to the line of flow.
drainage area	(Also drainage, watershed, catchment basin) The total surface area above a given point that would contribute to flow at that point in the event of runoff.
event	A storm which produces runoff, also a flood.
flood	A runoff event which causes flooding.
flooding	The temporary inundation of lands not normally subject to flowing or standing water which causes or threatens to cause damages.
flood frequency	(See recurrence interval)
flood hazard area	(Also flood plain or flood-prone area) Land adjacent to a channel or in a low area which is subject to flooding.
flood plain	(See flood hazard area)
flood profile	(Also profile) A plotted line showing the highest water surface elevation along a stream for a particular flood.
frequency	(See recurrence interval)
hydraulics	(Hydraulic analysis) General--the science that treats water in motion. For this report--the determination of the depth and velocity of various discharges at given cross sections.
hydrology	(Hydrologic analysis) General--the science that deals with the occurrence and behavior of water in the atmosphere, on the ground, and underground. For this report--the determination of peak rate of discharge from a given drainage area for various frequencies using various procedures including gage data analyses, regional regression analyses, and application of watershed modeling techniques.

GLOSSARY OF TERMS
(continued)

overland flow	Runoff which flows over the ground surface in a shallow layer as opposed to channelized runoff.
peak discharge	The highest discharge or rate of flow during a flood at a given point.
peak flood elevation	The highest stage or elevation reached by a flood at a given point.
recurrence interval	(Also return period, frequency) The average interval of time within which the magnitude of a flood will be equaled or exceeded. It can be expressed in years or percent chance. Example: A 25-year flood has a recurrence interval of 25 years. It will be equaled or exceeded once every 25 years on the average. There is a probability of 0.04 (or a 4 percent chance) that the 25-year flood will be equalled or exceeded in any given year. 2-year flood — 50 percent chance 10-year flood — 10 percent chance 50-year flood — 2 percent chance 100-year flood — 1 percent chance 500-year flood — 0.2 percent chance
return period	(See recurrence interval)
riparian area	The vegetated area and biotic community influenced by high water tables adjacent to rivers, streams, and other surface waters.
routing	(Also flood routing) The computation of the changes in the rise, peak, and fall of streamflow as a flood moves through a channel or reservoir.
runoff	(Also excess rainfall) That portion of rainfall which contributes to flow a channel or across the land surface.
watershed	(See drainage area)

APPENDIX H

BIBLIOGRAPHY

Appendix H

BIBLIOGRAPHY

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APPENDIX I

LEGAL REFERENCE

DEPARTMENT OF NATURAL RESOURCES AND CONSERVATION

CHAPTER 15

FLOODPLAIN MANAGEMENT ENGINEERING BUREAU

Sub-Chapter 1

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Rule 36.15.502 Floodway Delineation

36.15.503 Public Input on Proposed Designed Floodplains or Floodways

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Designated Floodway Minimum Standards

Rule 36.15.601 Uses Allowed Without Permits

36.15.602 Uses Requiring Permits

36.15.603 Permits for Water Diversions

36.15.604 Minimum Criteria for Permits

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36.15.606 Permits for Flood Control Work

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Flood Fringe Minimum Standards

Rule 36.15.701 Allowed Uses

36.15.702 Flood Proofing for Commercial and Industrial Structures

36.15.703 Prohibited Uses

Sub-Chapter 8

Designated Floodplain Only Minimum Standards

Rule 36.15.801 Allowed Uses Where Floodway Not Designated or No Flood Elevations

FLOODPLAIN MANAGEMENT

Sub-Chapter 9

Flood Proofing Requirements

Rule 36.15.901 Flood Proofing Requirements for Electrical Systems

36.15.902 Flood Proofing Requirements for Heating Systems

36.15.903 Flood Proofing Requirements for Plumbing Systems

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Sub-Chapter 1

Definitions

36.15.101 DEFINITIONS In addition to the definition of terms contained in section 76-5-103, MCA, and unless the context requires otherwise, as used in the Act and in this chapter:

(1) "Act" means Title 76, chapter 5, MCA, as amended.

(2) "Alteration" means any change or addition to an artificial obstruction that either increases the size of the artificial obstruction or increases its potential flood hazard. Maintenance of an artificial obstruction is not an alteration.

(3) "Artificial obstruction" means any obstruction which is not natural and includes any dam, diversion, wall, riprap, embankment, levee, dike, pile, abutment, projection, revetment, excavation, channel rectification, bridge, conduit, culvert, building, refuse, automobile body, fill or other analogous structure or matter in, along, across, or projecting into any 100-year floodplain which may impede, retard, or alter the pattern of flow of water, either in itself or by catching or collecting debris carried by the water, or that is placed where the natural flow of water would carry the same downstream to the damage or detriment of either life or property.

(4) "Base flood" means a flood having a one percent (1%) chance of being equalled or exceeded in any given year. A base flood is the same as a flood of 100-year frequency.

(5) "Base flood elevation" means the elevation above sea level of the base flood in relation to national geodetic vertical datum of 1929, unless otherwise specified.

(6) "Board" means the board of natural resources and conservation.

(7) "Channelization project" means the excavation and construction of an artificial channel for the purpose of diverting the entire flow of a watercourse or drainway from its established course.

(8) "Department" means the department of natural resources and conservation.

(9) "Establish" means to construct, place, insert, or excavate.

(10) "Flood fringe" means that portion of a designated floodplain outside the limits of a designated floodway.

(11) "Floodplain," means the area adjoining the watercourse or drainway which would be covered by the floodwater of a base flood except for sheetflood areas that receive less than 1 foot of water per occurrence and are considered zone b areas by the federal emergency management agency. The floodplain consists of the floodway and flood fringe.

(12) "Flood boundary" the designated floodplain boundary is based on base flood elevations. The mapped floodplain boundary may be used as a guide for determining whether property is within the designated floodplain, but the exact boundary shall be determined according to the base flood elevation.

(13) "Floodway," means the channel of a watercourse or drainway and those portions of the floodplain adjoining the channel which are reasonably required to carry and discharge the floodwater of any watercourse or drainway.

(14) "Lowest floor" means any floor used for living purposes, storage, or recreation. This includes any floor that could be converted to such a use.

(15) "Manufactured home" means a structure that is transportable in one or more sections, built on a permanent chassis, and designed to be used with or without a permanent foundation when connected to the required utilities. For floodplain management purposes it also includes park trailers, travel trailers, and other similar vehicles placed on a site for greater than 180 consecutive days.

(16) "Permit issuing authority" means the responsible political subdivision, if any, or the department if there is no responsible political subdivision.

(17) "Responsible political subdivision" means a political subdivision that has received board approval of its adopted land use regulations and administrative and enforcement procedures in accordance with section 76-5-302, MCA, and ARM 36.15.201 through 36.15.204.

(18) "Riprap" means stone, rock, concrete block, or analogous material that is placed along the banks or bed of a watercourse or drainway for the purpose of alleviating erosion.

(19) "Sheetflooding" means areas subject to 100-year flooding with depths less than one (1) foot. Sheetflood areas are generally removed from the main stream channel and have been identified as zone b by FEMA or as a sheetflood zone by the soil conservation service.

(20) "Start of construction" for purposes of these rules means the commencement of clearing, grading, filling or excavation for the purposes of preparing a site for construction.

(21) "Substantial improvement" means any repair, reconstruction, or improvement of a structure, the cost of which equals or exceeds fifty percent (50%) of the market value of the structure either:

(a) before the improvement or repair is started, or

(b) if the structure has been damaged, and is being restored, before the damage occurred. For the purposes of this definition, substantial improvement is considered to occur when the first construction to any wall, ceiling, floor, or other structural part of the building commences. The term does not include:

(i) any project for improvement of a structure to comply with existing state or local health, sanitary, or safety code specifications which are solely necessary to assure safe living conditions, or

(ii) any alteration of a structure listed on the national register of historic places or state inventory of historic places.

(22) "Suitable fill" means fill material which is stable, compacted, well graded, pervious, not adversely affected by water and frost, devoid of trash or similar foreign matter, tree stumps, or other organic material; and is fitting for the purpose of supporting the intended use and/or permanent structure.

(23) "Variance" means a grant or relief from the requirements of these rules which would permit construction in a manner that would otherwise be prohibited by these rules.

(24) "100 year frequency flood" - See "base flood".
(History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-208 and Sec. 76-5-404, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

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Sub-Chapter 2

Regulation and Enforcement

36.15.201 LOCAL REGULATION AND ENFORCEMENT (1) If a political subdivision adopts land use regulations that equal or exceed the minimum standards contained in sub-chapters 6 through 9 of these rules within the time specified and if the administrative and enforcement procedures for such regulations meet the requirements of these rules and are approved by the board in accordance with section 76-5-302, MCA, no permit will be required from the department. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-302, MCA; NEW, Eff. 9/4/74; EMERG, AMD, Eff. 9/4/75.)

36.15.202 BOARD APPROVAL OF LOCAL REGULATIONS AND ENFORCEMENT (1) Copies of all regulations and administrative and enforcement procedures proposed to be adopted by a political subdivision to meet the requirements of the Act and these rules shall be sent to the department for approval by the board.

(2) The department will notify the political subdivision by letter of board approval or disapproval.

(3) Any changes to the regulations or administrative and enforcement procedures proposed to be adopted by a political subdivision shall be sent to the department for approval by the board. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-302, MCA; NEW, Eff. 9/4/74; EMERG, AMD, Eff. 9/4/75; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.203 TIME LIMIT FOR ADOPTION OF LOCAL REGULATIONS (1) After a floodway or a floodplain has been designated by the board, the department shall notify the affected political subdivisions and set forth the date by which the political subdivision must adopt land use regulations and administrative and enforcement procedures in accordance with the Act and these rules. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-302, MCA; NEW, Eff. 9/4/74; EMERG, AMD, Eff. 9/4/75; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.204 LOCAL REGULATIONS - REQUIREMENTS (1) Land use regulations adopted by a local political subdivision in conformance with the Act and these rules may include zoning, building codes, and subdivision regulations adopted pursuant to other enabling statutory authority, such as Title 76, chapters 1 and 3; Title 76, chapter 2, part 3; and Title 76, chapter 2, parts 1 and 2, MCA; as well as regulations adopted under the authority given in sections 76-5-404 through 76-5-406, MCA.

(2) Any land use regulations and administrative and enforcement procedures adopted to comply with the Act and these rules must include the following:

(a) A permit is required prior to the new construction, substantial improvement or alteration of any artificial obstruction;

(b) Regulations governing the granting of permits must be at least as stringent as the minimum standards contained in these rules;

(c) Provisions for providing notice to the department, adjacent property owners, and the public of proposed actions requiring a permit or variance in accordance with these rules. Notice shall be published in a legal newspaper published or of general circulation in the area and shall include a brief description of the proposed activity. There shall be a period not less than fifteen days following publication of notice to receive comment regarding the proposed activity for consideration prior to issuance of a permit or variance. If the responsible political subdivision determines that comments warrant it, a hearing may be held to determine if the proposed issuance or denial of a permit or the proposed issuance or denial of a variance is in accordance with adopted regulations and these rules.

(d) The approval of the department must be obtained prior to the approval by the political subdivision pursuant to ARM 36.15.216(3) of any permit application that is in variance with the adopted regulations and these rules;

(e) Copies of all permits and variances granted must be sent to the department;

(f) Before the regulations are effective, all known property owners within the designated floodplain and designated floodway must be notified by mail by the political subdivision that their property is located within the designated floodplain or floodway and is subject to regulation. This notification provision shall not apply to political subdivisions that have adopted building codes requiring permits for new construction or to municipalities or counties that have received flood hazard boundary maps or flood insurance rate maps from the United States department of housing and urban development or the federal emergency management agency;

(g) A disclosure provision requiring all property owners with property in a designated floodplain or floodway, or their agents, to notify potential buyers that such property is located within the designated floodplain or floodway and is subject to regulation;

(h) An official must be hired or appointed with the authority to review permit applications and proposed uses or construction to determine compliance with the Act, these rules, and the regulations adopted by the political subdivision.

(3) The regulations may also include the following:

(a) requirements that existing nonconforming uses be inspected and documented to insure future compliance;

(b) the imposition of a reasonable application fee for the processing of permit applications. The fee may cover the costs of providing public notice, processing permits and variances, and performing sufficient field inspections to ensure compliance with these rules. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-302, MCA; NEW, Eff. 9/4/74; EMERG, AMD, Eff. 9/4/75; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.205 BOARD REVIEW OF LOCAL ENFORCEMENT (1) The department shall periodically report to the board on permit and variances filed, complaints received, and any other relevant information on the administration and enforcement of local regulations by the responsible political subdivision.

(2) If the board determines that the responsible political subdivision has failed to comply with the intent, purposes, or provisions of the local regulations, these rules, or the Act, the board may, after hearing, suspend the powers of the responsible political subdivision. In accordance with ARM 36.15.209 the department shall enforce the minimum standards adopted by the board until such time as the board determines that the responsible political subdivision will comply. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-302(2), MCA; NEW, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.206 through 36.15.208 reserved

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36.15.209 DEPARTMENT REGULATION AND ENFORCEMENT (1) If the political subdivision fails to adopt land use regulations and administrative and enforcement procedures that meet or exceed the minimum standards required by the Act and these rules within the time specified, or fails to enforce the regulations, the minimum standards set forth in the Act and these rules regulating the designated floodplain or floodway will be enforced by the department.

(2) An application to the department for a permit shall be made on a standard form furnished by the department and shall include all applicable information listed on the form.

(3) The permit, if approved, will be given by the department on a standard form.

(4) A permit application requiring an environmental impact statement will be specifically approved or denied by the department only after full compliance with the provisions of the Montana Environmental Policy Act. Normally, the period of time required for review of these permit applications will be from 60 to 120 days. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-301 and 76-5-405, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.210 ENVIRONMENTAL IMPACT STATEMENTS
(IS HEREBY REPEALED) (History: Sect. 76-5-208, MCA; IMP, Sec. 76-5-405, MCA; NEW, Eff. 9/4/74, REP, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.211 through 36.15.215 reserved

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36.15.216 PERMITS - CRITERIA - TIME LIMITS (1) Permits shall be granted or denied by the permit issuing authority on the basis of whether the proposed new construction, substantial improvement, or alteration of an artificial obstruction meets the requirements of the Act and the minimum standards established by the board in these rules.

(2) Additional factors that shall be considered for every permit application are:

(a) the danger to life and property from backwater or diverted flow caused by the obstruction;

(b) the danger that the obstruction will be swept downstream to the injury of others;

(c) the availability of alternative locations;

(d) the construction or alteration of the obstruction in such manner as to lessen the danger;

(e) the permanence of the obstruction;

(f) The anticipated development in the foreseeable future of the area which may be affected by the obstruction; and,

(g) such other factors as are in harmony with the purposes of the Act and these rules.

(3) A permit application is considered to have been automatically granted 60 days after receipt of the application, unless the permit issuing authority notifies the applicant before the 60th day that additional information is required, more time is required to process the application, or that the permit is denied. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-405 and 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1988 MAR p. 1537, Eff. 7/15/88; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.217 WAIVER OF PERMIT FOR EMERGENCY REPAIR OR REPLACEMENT (1) Emergency repair to and/or replacement of severely damaged public transportation facilities, public water and sewer facilities, and flood control works may be authorized and permit requirements waived if:

(a) Upon notification and prior to the emergency repair and/or replacement, the permit issuing authority determines that an emergency condition warranting immediate action exists; and

(b) The permit issuing authority agrees upon the nature and type of proposed emergency repair and/or replacement.

(2) Authorization to undertake emergency repair and/or replacement work may be given verbally if the permit issuing authority feels that a written authorization would unduly delay the emergency work. Such verbal authorization must be followed by a written authorization stating the emergency condition, the type of emergency work agreed upon, and a notation that verbal authorization had been previously given. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-405 and Sec. 76-5-406, MCA; NEW, 9/4/74.)

36.15.218 VARIANCES (1) The permit issuing authority may grant a variance for the new construction, substantial improvement or alteration of an artificial obstruction that is not in compliance with the minimum standards contained in these rules only if:

(a) the proposed use would not increase flood hazard either upstream or downstream in the area of insurable buildings;

(b) refusal of a variance would because of exceptional circumstances cause a unique or undue hardship on the applicant or community involved;

(c) the proposed use is adequately floodproofed;

(d) reasonable alternative locations outside the designated floodplain are not available. (History: Sec. 76-5-405 and 76-5-406, MCA; IMP, Sec. 76-5-405 and 76-5-406, MCA; NEW, 1989 MAR p. 1665, Eff. 10/27/89.)

Sub-Chapters 3 and 4 reserved

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Sub-Chapter 5

Floodplain and Floodway Delineations

36.15.501 FLOODPLAIN AND FLOODWAY DELINEATION - DATA USED - HYDROLOGICAL CERTAINTY (1) All floodplain delineation studies, reports, maps, and water surface profiles used by the department and board to establish designated floodplains shall be based upon the base flood.

(2) Each floodplain delineation study arranged by the department will, insofar as time and funds permit, include a water surface profile showing the elevation of the base flood and a suggested designated floodway.

(3) The department and board will also utilize flood hazard maps and data provided by the U.S. department of housing and urban development or the federal emergency management agency for the national flood insurance program as a basis for establishing the designated floodplain. Such maps will delineate the boundaries of the base flood but will not generally include flood elevations or floodway data.

(4) Designated floodplains established for areas where flood elevations and/or floodway data are lacking shall be regulated in accordance with ARM 36.15.801.

(5) The designation of floodplains and floodways shall be based upon reasonable hydrological certainty. Flood hazard maps that do not include floodway data or base flood elevations constitute a rebuttable presumption of reasonable hydrological certainty.

(6) The designated floodplain boundary is based on base flood elevations. The mapped floodplain boundary may be used as a guide for determining whether property is within the designated floodplain, but the exact boundary shall be determined according to the base flood elevation. If the local administrator determines it is unclear whether property is in or out of the floodplain, the local administrator shall require the applicant to provide additional information which may include elevations obtained through a level survey performed by a professional engineer or register land surveyor.
(History: Sec. 76-5-201, 76-5-202, and 76-5-208, MCA; IMP, Sec. 76-5-201 and 76-5-202, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.502 FLOODWAY DELINEATION (1) The delineations of a designated floodway shall be based on the channel of the water course or drainway and those portions of the adjoining floodplain which are reasonably required to carry the discharge of the base flood without cumulatively increasing the water surface more than one half foot.

(2) In areas having appreciable urban development on the floodplain, the outer boundary lines of the floodway may generally follow the riverward limits of development provided that:

(a) The calculated elevation of the base flood would not be increased more than 0.5 of a foot as a result of any adjustment to the floodway;

(b) Floodway lines are compatible with local land use plans; and,

(c) The flood fringe does not contain appreciable areas with flood velocities greater than 3 feet per second or flood depths greater than 3 feet.

(3) After delineation of a suggested designated floodway and prior to the public hearing to consider the floodway delineation, the department shall meet with local planning officials to consider possible adjustments due to land use considerations. No adjustments in floodway width or location may be made if the theoretical increase in flood heights would exceed 0.5 foot or if adjustments affect private property rights. (History: Sec. 76-5-201, 76-5-202, and 76-5-208, MCA; IMP, Sec. 76-5-201 and 76-5-202, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.503 PUBLIC INPUT ON PROPOSED DESIGNATED FLOODPLAINS OR FLOODWAYS (1) The department shall at least 3 weeks prior to any hearing held for the purpose of establishing a designated floodplain or floodway furnish the affected political subdivisions maps and other data showing the proposed designated floodplain or floodway together with a letter requesting the political subdivision to furnish any pertinent data on flood hazards.

(2) Notice of a hearing or order of the board establishing or altering designated floodplains and floodways shall be published once each week for three (3) consecutive weeks in a legal newspaper published or of general circulation in the area involved, the last publication of notice shall be not less than 10 days prior to the hearing or order by the board.

(3) The department shall also issue news releases at least 3 weeks prior to any hearing requesting the public to submit any available data concerning flood hazard, flood elevations, or the proposed designated floodplain or floodway boundaries. (History: Sec. 76-5-202 and 76-5-204, MCA; IMP, Sec. 76-5-201 through 76-5-204, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.504 LOCAL GOVERNMENT ADJUSTMENTS TO PROPOSED FLOODWAY DELINEATION (1) After the delineation of a suggested designated floodway by the department and prior to the public hearing to consider the floodway delineations, the department shall meet with local governmental and planning officials to consider possible adjustments due to local land use consideration.

(2) No adjustments in floodway width or location may be made, however, if such adjustments would theoretically increase flood heights beyond the permissible limits noted in ARM 36.15.502. (History: Sec. 76-5-208, MCA, Sec. 76-5-201 and Sec. 76-5-202, MCA; NEW, 9/4/74.)

36.15.505 ALTERATION OF FLOODPLAINS AND FLOODWAYS

(1) The board may alter a designated floodplain or designated floodway, after a public hearing, when sufficient data become available.

(a) When scientific or technical flood data shows that the base flood elevation was erroneously established and the designation of the floodplain boundary was therefore incorrect.

(b) When property has been raised to a level above the base flood elevation by suitable fill provided that:

(i) the filled area is contiguous to areas naturally above the base flood elevation and not within the designated floodplain;

(ii) the filled area is a minimum of 2 feet above the base flood elevation;

(iii) the fill is suitable material according to definition in ARM 36.15.101 and is not subject to settlement and has been compacted to 95 percent of the maximum density obtainable with the standard proctor test method of the American society for testing and materials (ASTM Standard D-698) or equivalent;

(iv) no portion of the fill is within the floodway;

(v) the fill slope must not be steeper than 1 1/2 horizontal to 1 vertical unless substantiating data justifying a steeper slope is provided and adequate erosion protection is provided for fill slopes exposed to floodwaters. The erosion protection for fill slopes exposed to velocities of four feet per second and less may consist of vegetative cover consisting of grasses or similar undergrowth as approved by the permit issuing authority. Slopes exposed to velocities greater than four feet per second shall be protected by armoring with stone or rock slope protection;

(vi) compaction of earthen fill and erosion protection measures must be certified as meeting these criteria by a registered professional engineer;

(vii) the fill does not increase the elevation of the base flood in areas of existing development.

(c) when areas have been protected by a properly engineered flood protection project provided that:

(i) dams are designed and operated for flood control purposes and constructed in accordance with acceptable safety standards and the Montana Dam Safety Act;

(ii) levees and floodwalls comply with ARM 36.15.606 and are publicly owned and maintained. Minimum freeboard above the base flood elevation shall be three feet with an additional foot 100 feet either side of a structure such as bridges. An additional 1/2 foot above the minimum is required at the upstream end of the levee, tapering to the minimum at the downstream end. The levee must be designed and constructed to offer base flood protection without human supplementation. Human intervention is only acceptable for the operation of closure structures such as gates or stop logs. A levee system designed for human operation of closures are acceptable provided that:

(A) adequate warning time exists for the operation of closures before floodwaters reach the base of the closure,

(B) the closure is an integral part of the system during operation,

(C) operation and maintenance of closure structures are responsibilities mandated by local regulation with periodic operation performed for testing and training purposes,

(D) a formal operation plan is available and capable of being implemented.

(iii) dams and levees must be designed by a registered professional engineer and flood protection certified as adequate to provide protection from the base flood;

(iv) floodway channels designed by a registered professional engineer may carry less than the discharge of the base flood provided that they do not increase the extent of flooding.

(2) No alteration of a designated floodplain is required when property located within the flood fringe is naturally above the base flood elevation as proven by a certified elevation survey provided by a registered professional engineer or licensed land surveyor. (History: Sec. 76-5-204, MCA; IMP, Sec. 76-5-204, MCA; NEW, 1989 MAR p. 1665, Eff. 10/27/89.)

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Sub-Chapter 6

Designated Floodway Minimum Standards

36.15.601 USES ALLOWED WITHOUT PERMITS (1) The following open space uses shall be allowed without a permit anywhere within the designated floodway provided that they are not prohibited by any other ordinance or statute and provided that they do not require structures other than portable structures, fill, or permanent storage of materials or equipment:

(a) agricultural uses;

(b) industrial-commercial uses such as loading areas, parking areas, and emergency landing strips;

(c) private and public recreational uses such as golf courses, driving ranges, archery ranges, picnic grounds, boat-launching ramps, swimming areas, parks, wildlife management and natural areas, game farms, fish hatcheries, shooting preserves, target ranges, trap and skeet ranges, hunting and fishing areas, and hiking and horseback riding trails;

(d) forestry, including processing of forest products with portable equipment; and

(e) residential uses such as lawns, gardens, parking areas, and play areas.

(2) In addition to the uses specified in the preceding subsection, the following uses and their accessories do not in the judgment of the board endanger health or safety or cause increased flood heights and shall thus be allowed without a permit in the designated floodway:

(a) irrigation and livestock supply wells provided that they are located at least 500 feet from domestic water supply wells; and

(b) fences, except permanent fences crossing channels. (History: Sec. 76-5-208 and 76-5-406, MCA; IMP, Sec. 76-5-401, Sec. 76-5-405, and 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.602 USES REQUIRING PERMITS In addition to the uses allowed under ARM 36.15.601, the following artificial obstructions may be permitted within the designated floodway subject to the issuance of a permit by the permit issuing authority under the conditions set forth in this rule and ARM 36.15.603 and 36.15.604:

(1) excavation of material from pits or pools provided that:

(a) a buffer strip of undisturbed land of sufficient width to prevent flood flows from channeling into the excavation is left between the edge of the channel and the edge of the excavation;

(b) the excavation meets all applicable laws and regulations of other local and state agencies; and

(c) excavated material is stockpiled outside the designated floodway;

(2) railroad, highway, and street stream crossings provided that the crossings are designated to offer minimal obstruction to flood flow;

(3) limited filling for highway, street, and railroad embankments not associated with stream crossings provided that:

(a) reasonable alternative transportation routes outside the designated floodway are not available; and

(b) such floodway encroachment is located as far from the stream channel as possible;

(4) Buried or suspended utility transmission lines provided that:

(a) suspended utility transmission lines are designed such that the lowest point of the suspended line is at least 6 feet higher than the elevation of the base flood;

(b) towers and other appurtenant structures are designed and placed to withstand and offer minimal obstruction to flood flows; and

(c) utility transmission lines carrying toxic or flammable materials are buried to a depth at least twice the calculated maximum depth of scour for the base flood. The maximum depth of scour may be determined from any of the accepted hydraulic engineering methods, but the final calculated figure shall be subject to approval by the permit issuing authority;

(5) storage of materials and equipment provided that:

(a) the material or equipment is not subject to major damage by flooding and is properly anchored to prevent flotation or downstream movement; or,

(b) the material or equipment is readily removable within the limited time available after flood warning. Storage of flammable, toxic, or explosive materials shall not be permitted;

(6) domestic water supply wells provided that:

(a) they are driven or drilled wells located on ground higher than surrounding ground to asure positive drainage from the well;

(b) well casings are watertight to a distance of at least 25 feet below the ground surface;

(c) water supply and electrical lines have a watertight seal where the lines enter the casing;

(d) all pumps and elctrical lines and equipment are either of the submersible type or are adequately floodproofed; and

(e) check valves are installed on main water lines at wells and at all building entry locations;

(7) buried and sealed vaults for sewage disposal in recreational areas provided that they meet applicable laws and standards administered by the department of health and environmental sciences;

(8) Public or private campgrounds provided that:

(a) access roads require only limited fill and do not obstruct or divert flood waters; and,

(b) no dwellings or permanent mobile homes are allowed;

(9) structures accessory to the uses permitted in this subsection such as boat docks, marinas, sheds, permanent fences crossing channels, picnic shelters and tables, and toilets provided that:

(a) the structures are not intended for human habitation;

(b) the structures will have a low flood damage potential;

(c) the structures will insofar as possible be located on ground higher than the surrounding ground and as far from the channel as possible;

(d) the structures will be constructed and placed so as to offer a minimal obstruction to flood flows;

(e) the structures will be firmly anchored to prevent flotation; and,

(f) service facilities within these structures such as electrical, heating, and plumbing facilities are floodproofed in accordance with ARM 36.15.901 through 36.15.903;

(10) all other artificial obstructions not specifically listed in this subsection or in ARM 36.15.606, not allowed under ARM 36.15.601, and not prohibited under ARM 36.15.605. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.603 PERMITS FOR WATER DIVERSIONS (1) As provided in the Montana Water Use Act of 1973, sections 85-2-302 and 85-2-402, MCA, all new surface water diversions and changes in place of diversion after July 1, 1973, require permits or approval, respectively, from the department. Within designated floodways, the department shall review each proposed diversion and change in place of diversion to determine if flood flows may be affected.

(2) If it appears that a proposed diversion or change in place of diversion may significantly affect flood flows, the department may require the applicant to provide additional information and to apply for a permit with the permit issuing authority under Title 76, chapter 5, MCA, as amended.

(3) A permit under Title 76, Chapter 5, MCA, as amended, shall not be granted if in the judgment of the permit issuing authority:

(a) the proposed diversion will increase the upstream elevation of the base flood a significant amount (0.5 of a foot or as otherwise determined by the permit issuing authority);

(b) the proposed diversion is not designed and constructed to minimize potential erosion from a base flood; and,

(c) any permanent diversion structure crossing the full width of the stream channel is not designed and constructed to safely withstand up to a base flood. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.604 MINIMUM CRITERIA FOR PERMITS (1) In addition to the requirements of ARM 36.15.602 and 36.15.603, a permit shall not be approved for new construction, substantial improvement, or alteration of an artificial obstruction under this rule if it will increase the upstream elevation of the base flood 0.5 of a foot or as otherwise determined by the permit issuing authority or significantly increase flood velocities. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.605 PROHIBITED USES (1) The following artificial obstructions are prohibited within the designated floodway except as allowed by permit under ARM 36.15.602 through 36.15.604 and ARM 36.15.606:

(a) a building for living purposes or place of assembly or permanent use by human beings;

(b) a structure or excavation that will cause water to be diverted from the established floodway, cause erosion, obstruct the natural flow of water, or reduce the carrying capacity of the floodway;

(c) the construction or permanent storage of any object subject to floatation or movement during flood level periods.

(2) The following artificial obstructions are also prohibited within the designated floodway:

(a) mobile homes and manufactured homes;

(b) commercial buildings;

(c) solid and hazardous waste disposal and individual or multiple family sewage disposal systems;

(d) storage of toxic, flammable, hazardous, or explosive materials. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-403 and 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.606 PERMITS FOR FLOOD CONTROL WORKS (1) Since structural flood control works often significantly obstruct and affect floodway flow capacity, the following flood control measures shall be allowed within designated floodways subject to the issuance of a permit by the permit issuing authority and certification by a registered professional engineer of compliance with the conditions set forth in this rule:

(a) Flood control levees and floodwalls if:

(i) the proposed levees and floodwalls are designed and constructed to safely convey the base flood;

(ii) the cumulative effect of the levees and floodwalls combined with allowable flood fringe encroachments does not increase the unobstructed elevation of the base flood more than 0.5 of a foot at any point;

(b) riprap, except that which is hand placed, if:

(i) the riprap is designed to withstand the base flood;

(ii) the riprap does not increase the elevation of the base flood;

(iii) the riprap will not increase erosion upstream, downstream, or across stream from the riprap site;

(c) channelization projects if they do not significantly increase the magnitude, velocity, or elevation of the flood;

(d) dams provided that:

(i) they are designed and constructed in accordance with approved safety standards, and the Montana Dam Safety Act;

(ii) they will not increase flood hazards downstream either through operational procedures or improper hydrologic design.

(2) The permit issuing authority may establish either a lower or higher permissible increase in the elevation of the base flood than that established in subsection (1)(a)(ii) for individual levee projects based on consideration of the following criteria:

(a) the proposed levees and floodwalls, except those to protect agricultural land only, are constructed at least 3 feet higher than the elevation of the base flood;

(b) the estimated cumulative effect of other reasonably anticipated future permissible uses;

(c) the type and amount of existing flood prone development in the affected area;

(d) no detrimental impact occurs to existing or foreseeable development. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

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Sub-Chapter 7

Flood Fringe Minimum Standards

36.15.701 ALLOWED USES (1) All uses allowed in the designated floodway without a permit under ARM 36.15.601 shall also be allowed without a permit in the flood fringe.

(a) In addition, individual or multiple family subsurface sewage disposal systems are allowed only when they are reviewed and approved under laws and regulations administered by the department of health and environmental sciences or the local health board.

(2) All uses allowed in the designated floodway subject to the issuance of a permit under ARM 36.15.602 through 36.15.604 and ARM 36.15.606 shall also be allowed in the flood fringe subject to the issuance of a permit.

(3) In addition, structures including, but not limited to residential, commercial, and industrial structures, and suitable fill shall be allowed by permit from the permit issuing authority within the flood fringe subject to the following conditions and the requirements of ARM 36.15.702 and 36.15.901 through 36.15.903:

(a) Such structures or fill must not be prohibited by any other statute, regulation, ordinance, or resolution;

(b) Such structures or fill must be compatible with local comprehensive plans, if any;

(c) Roads, streets, highways, and rail lines shall be designed to minimize increases in flood heights. Where failure or interruption of transportation facilities would result in danger to the public health or safety, the facilities shall be located 2 feet above the elevation of the base flood;

(d) Public or private structures and facilities for liquid or solid waste treatment and disposal must be floodproofed to insure that no pollutants enter flood waters. These facilities must be allowed and approved under laws and standards administered by the department of health and environmental sciences prior to any approval given by the permit issuing authority; and

(e) Agricultural structures that have a low flood damage potential such as sheds, barns, shelters, and hay and grain storage structures must meet the requirements of ARM 36.15.602 (9). (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-402, 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.702 FLOOD PROOFING FOR RESIDENTIAL, COMMERCIAL AND INDUSTRIAL STRUCTURES (1) The new construction, substantial improvement, and alteration of residential structures shall meet the following conditions:

(a) Residential structures shall be constructed on suitable fill with a permanent foundation such that the lowest floor (including basement) level is 2 or more feet above the base flood elevation. The suitable fill shall be at a level no lower than the base flood elevation extending 15 feet at that elevation beyond the structure in all directions. Where existing streets, utilities, lot dimensions, or additions onto existing structures, make strict compliance with this provision impossible, the permit issuing authority may authorize a lesser amount of fill or alternative flood proofing measures. Alternative flood proofing measures must, at a minimum, meet the conditions of ARM 36.15.702 and ARM 36.15.901 through 36.15.903.

(i) The new placement of manufactured and mobile homes must be elevated on fill with a permanent foundation as prescribed for residential structures.

(ii) Replacement manufactured and mobile homes in an existing mobile home park or subdivision may, instead of using suitable fill, be elevated on a concrete or mortared block foundation, or other suitable permanent foundation, and anchored to prevent flotation or downstream movement.

(2) The new construction, substantial improvement, and alteration of commercial and industrial structures shall be elevated on fill as prescribed for residential structures in ARM 36.15.702(1) or flood proofed to a level no lower than 2 feet above the base flood elevation. Flood proofing shall be accomplished in accordance with ARM 36.15.901 through 36.15.903 and shall further include the following:

(a) If the structure is designed to allow internal flooding of the lowest floor, use of the floor shall be limited to such uses as parking, loading areas, and storage of equipment or materials not appreciably affected by flood water. Further, the floors and walls shall be designed and constructed of materials resistant to flooding up to an elevation of 2 or more feet above the elevation of the base flood. Structures designed to allow internal flooding shall be designed to equalize hydrostatic flood forces on exterior walls by allowing for the exit and entry of flood waters.

(b) Structures whose lowest floors are used for purposes other than parking, loading or storage of materials resistant to flooding shall be flood proofed up to an elevation no lower than 2 feet above the elevation of the base flood. Flood proofing shall include impermeable membranes or materials for floors and walls and watertight enclosures for all windows, doors, and other openings. These structures shall be designed to withstand the hydrostatic pressures and hydrodynamic forces resulting from the base flood.

(c) The new construction, substantial improvement and alteration of commercial or industrial structures floodproofed according to these requirements must be designed and flood proofing measures certified as adequate by a registered professional engineer or architect. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.703 PROHIBITED USES The following artificial obstructions and nonconforming uses are prohibited within the flood fringe:

(1) solid and hazardous waste disposal; and

(2) storage of toxic, flammable, hazardous, or explosive materials. Storage of petroleum products may be allowed by permit if stored on compacted fill at least 2 feet above the elevation of the base flood and anchored to a permanent foundation that is properly anchored to the ground.

(History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

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Sub-Chapter 8

Designated Floodplain Only Minimum Standards

36.15.801 ALLOWED USES WHERE FLOODWAY NOT DESIGNATED OR NO FLOOD ELEVATIONS (1) For those watercourses or drainways in which there is a designated floodplain but not a designated floodway or where no flood elevations are available, all uses allowed in a designated floodway under ARM 36.15.601 without a permit shall also be allowed without a permit in such designated floodplain.

(2) All other uses within the designated floodplain shall require permits from the permit issuing authority. The following conditions insofar as each is applicable shall be attached to each permit approval:

(a) If the elevation of the base flood is available, residential structures must be built on compacted fill as specified in ARM 36.15.702(1). If such elevation is not available, the highest known historical flood elevation may be used to establish fill heights;

(b) If the elevation of the base flood is available, commercial and industrial structures must meet the flood proofing requirements set forth in ARM 36.15.702 (2). If such elevation is not available, the highest known historical flood elevation may be used to establish flood proofing heights;

(c) Proposed structures must be anchored to prevent flotation or collapse and must be located as far from stream channels as is practicable; and

(d) Sanitary sewage systems must be allowed and approved under laws and standards administered by the department of health and environmental sciences or the local health board.

(3) Where a proposed development within such designated floodplain may significantly increase flood velocities or depths, the permit issuing authority may require a permit applicant to furnish additional hydraulic and survey information before acting upon the permit application. This information may include, but is not limited to, any of the following:

(a) valley cross sections of the watercourse and adjoining floodplain;

(b) certification by a qualified professional engineer that floodproofing measures are reasonably adequate to protect against major flood damages; or

(c) a hydrologic study documenting probable effect on upstream or downstream property owners.

(4) Permits for such proposed developments may be modified or denied if the additional information shows that proposals would increase flood damages to other properties or would cause a threat to the health or safety of its occupants. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-402, 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

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Sub-Chapter 9

Flood Proofing Requirements

36.15.901 FLOOD PROOFING REQUIREMENTS FOR ELECTRICAL SYSTEMS (1) All electrical service materials, equipment, and installation for uses permitted with or without a permit in a designated floodplain or floodway shall conform to the following conditions:

(a) All incoming power service equipment including all metering equipment, control centers, transformers, distribution and lighting panels, and all other stationary equipment must be located at least 2 feet above the elevation of the base flood;

(b) Portable or movable electrical equipment may be placed below the elevation of the base flood provided that the equipment can be disconnected by a single plug-and-socket assembly of the submersible type;

(c) The main power service line shall have automatically operated electrical disconnect equipment or manually operated electrical disconnect equipment located at an accessible remote location outside the designated floodplain and above the elevation of the base flood; and

(d) All electrical wiring systems installed below the elevation of the base flood shall be suitable for continuous submergence and may not contain fibrous components. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-401 through 76-5-402, and Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.902 FLOODPROOFING REQUIREMENTS FOR HEATING SYSTEMS (1) Heating systems for allowed and permitted floodplain and floodway uses shall conform to the following conditions:

(a) Float operated automatic control valves must be installed in supply lines to gas furnaces so that the fuel supply is automatically shut off when flood waters reach the floor level where the furnaces are located;

(b) Manually operated gate valves that can be operated from a location above the elevation of the base flood shall also be provided in gas supply lines; and

(c) Electric heating systems must be installed in accordance with ARM 36.15.901. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-401 through 76-5-402, and Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

36.15.903 FLOOD PROOFING REQUIREMENTS FOR PLUMBING SYSTEMS (1) Plumbing systems for allowed and permitted floodplain and floodway uses shall conform to the following conditions:

(a) Sewer lines, except those to buried and sealed vaults, must have check valves installed to prevent sewage backup into permitted structures; and

(b) All toilet stools, sinks, urinals, and drains must be located such that the lowest point of possible water entry is at least 2 feet above the elevation of the base flood. (History: Sec. 76-5-208, MCA; IMP, Sec. 76-5-401 through 76-5-402, and Sec. 76-5-404 through 76-5-406, MCA; NEW, Eff. 9/4/74; AMD, 1989 MAR p. 1665, Eff. 10/27/89.)

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